ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND ALEX. RICHARDSON.

VOL. CXIV.—FROM JULY TO DECEMBER, 1922.

London:

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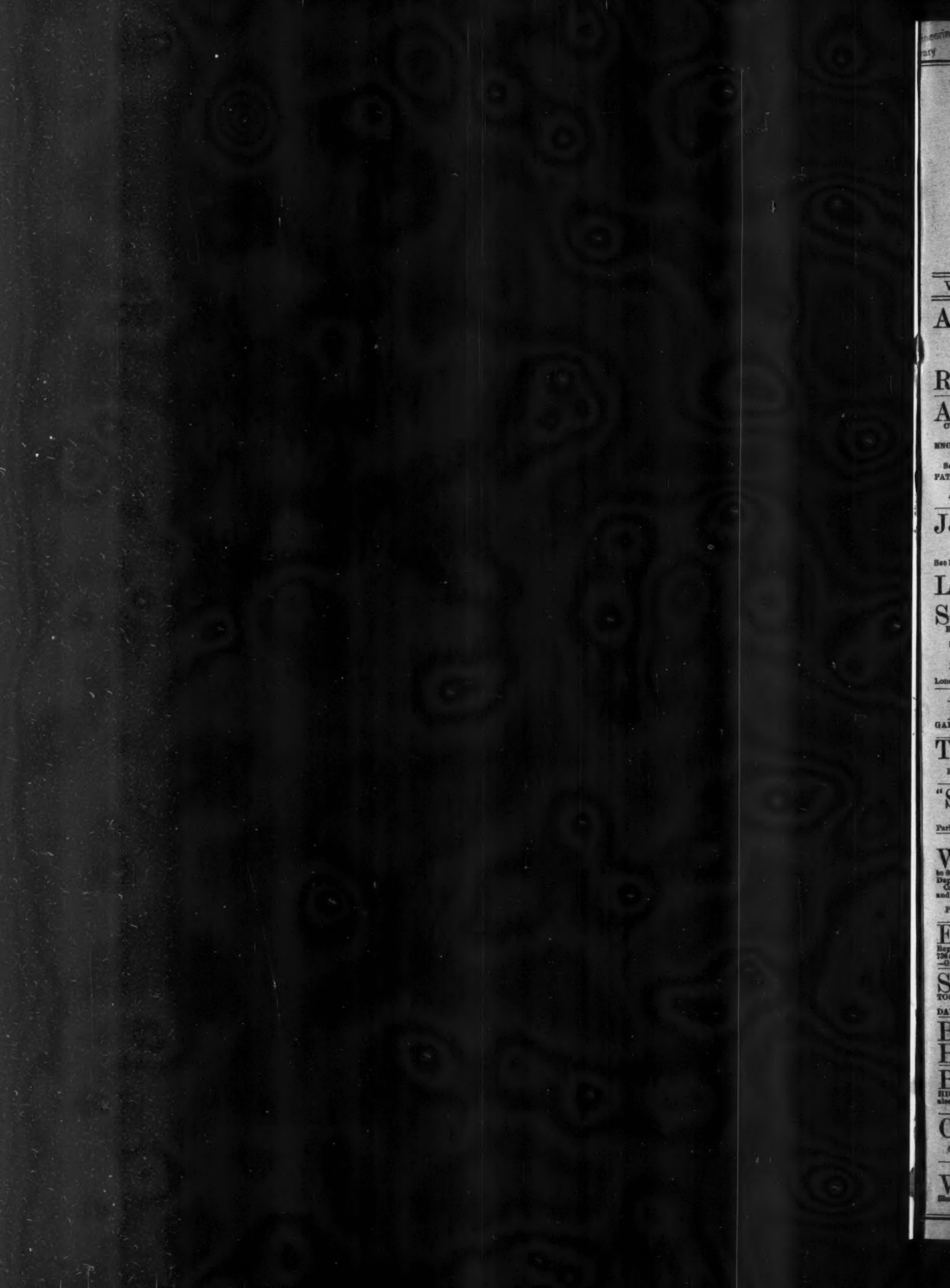

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JUL 19 1922

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VOL. CXIV.—No. 2949.] *LONDON: FRIDAY, JULY 7, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisement, page 26. 9953

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See Advertisement page 63, June 30. 940

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See Full Page Advt., page 56, June 23.

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See Advt. page 80, June 30.
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The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

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For each copy of the Specification a fee of £2 will be charged, which fee is not returnable. Tenders enclosed in sealed envelopes endorsed "Tender for Locomotives," must be delivered at the Company's Offices, not later than Twelve noon, on Wednesday, 26th July, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.

100, Gresham House,
Old Broad Street,
London, E.C. 2,
6th July, 1922. U 634

COUNTY BOROUGH OF BOURNEMOUTH.

Tenders are Invited for New

DECK JOISTS DECKING, etc., required on the Bournemouth Pier.

Form of Tender, Conditions, Specification and Bill of Quantities, can be obtained of the Borough Engineer, Mr. F. P. Dolamore, at whose office the drawings can be seen on or after Monday morning, the 10th July, 1922, provided the sum of £1 1s. has been previously deposited in respect of each tender with the undersigned, which deposit shall become forfeited unless a Tender complying with the conditions be sent in.

Sealed Tenders are to be forwarded in special envelopes which will be furnished for the purpose, to the Town Clerk, Town Hall, Bournemouth, not later than Noon on Wednesday, the 26th July, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

F. P. DOLAMORE, F.S.I.,
Borough Engineer & Surveyor.

Town Hall,
Bournemouth.
4th July, 1922. U 663

LONDON COUNTY COUNCIL.

Tenders are Invited for the

SUPPLY of SEVEN PETROL DRIVEN MOTOR FIRE ENGINES for the London Fire Brigade. The type of fire engine required may be seen by appointment on application to the Chief Officer, London Fire Brigade, 94, Southwark Bridge Road, S.E. 1.

Instructions for Tender and Form of Tender, with Schedules annexed, can be obtained on application to the Clerk of the Council, at the County Hall, Westminster Bridge, S.E. 1 (Room No. 210A), on payment of the sum of £1 1s. 0d., which amount will be returnable provided a *bona fide* Tender is sent in and not subsequently withdrawn.

Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Westminster Bridge, S.E. 1, not later than Eleven a.m. on 18th July, 1922. No Tender received after that time will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. U 656

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

COPPER RODS.

Specifications and forms of Tender will be available at the Company's offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Copper Rods," must be left with the undersigned not later than 12 Noon on Friday the 21st July, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 8, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1.
6th July, 1922. U 688

LIVERPOOL CORPORATION WATERWORKS.

TRUNK MAIN FROM PRESCOT TO LIVERPOOL. CONTRACT NO. 1.

TO IRON PIPE FOUNDERS.

The Water Committee of the Liverpool Corporation is prepared to receive

Tenders from Manufacturers

of Iron Pipes for the SUPPLY of about 6700 tons of CAST IRON PIPES, of 42 inches and 40 inches internal diameter, together with a number of SPECIAL CASTINGS, in accordance with a Specification and Drawings prepared by the Water Engineer, copies of which may be inspected at the Water Engineer's Office, Alexandra Buildings, 55, Dale Street, Liverpool, on and after Thursday, the 6th day of July, 1922. Copies of the Specification and Form of Tender may be obtained upon payment of a deposit Two Guineas, which will be repayable upon receipt of a *bona fide* Tender, and return of the documents and drawings issued.

Tenders, endorsed "Tender for Cast Iron Pipes," are to be sent through the post in a sealed envelope to the Town Clerk's Office, Municipal Buildings, Liverpool, addressed to the Chairman of the Water Committee, so as to be delivered not later than Twelve o'clock Noon, on Tuesday, the 18th July, 1922.

The Water Committee do not bind themselves to accept the lowest or any Tender.

G. HAMMOND STHERTON,
Town Clerk.

Municipal Buildings, Liverpool.
5th July, 1922. U 677

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, Are prepared to receive

Tenders for the Supply of:—

(1) Firebricks and Fireclay.
(2) Helical Springs.
(3) Spring Steel.
(4) Rolling Stock.
(5) Brass and Copper Tubes and Sheets.
(6) Buffers for Broad Gauge Wagons.
(7) Metals.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Firebricks and Fireclay," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 14th July, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1, 2, 3, 4, and 5, and £1 for each copy of Specifications Nos. 6 and 7.

Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 8, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
20th June, 1922. U 670

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Tenders are Invited for the

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Two Sturtevant BLOWERS, outlet 15 in. dia.
Further particulars may be had from the Engineer at the Gas Works.

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CHAIRMAN OF THE GAS COMPANY,
Gas Offices,
Onslow Street,
Guildford.

WILLIAM TITLEY,
Secretary. U 646

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

WHEELS AND AXLES for Rolling Stock.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tenders for Wheels and Axles for Rolling Stock," must be left with the undersigned not later than Twelve Noon on Friday, the 28th July, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specification.

Copies of the Drawings may be obtained at the office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 8, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1.
6th July, 1922. U 689

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—
No. 1. STEEL TYRES for Carriages and Wagons. Fee for Specification £1.
No. 2. CAST IRON WATER PIPES, etc. Fee for Specification 10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Tyres for Carriages and Wagons," or, as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 18th July, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 5th July, 1922. U 704

ROYAL BURGH OF KIRKCALDY.

ELECTRICITY WORKS, VICTORIA ROAD.

The Provost, Magistrates, and Council invite

Tenders for the Following

WORK:—

SPECIFICATION No. 3.—STEELWORK FOR BUILDING ANNEXE.

A copy of the Specification can be seen at and obtained from the Offices of Messrs. KENNEDY and DONKIN, 8, Broadway, Westminster, S.W. 1, on and after Monday, July 10th, upon payment of a deposit of £2 2s. (cheque, postal or money order). An additional copy of the Specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned after the receipt of a *bona fide* Tender, and on the return of the Specification.

Tenders on the prescribed Form, enclosed in sealed envelopes, and addressed on the outside:—
"Electricity Supply. Tender to Specification No. 3."
must be delivered at the office of the undersigned not later than Ten a.m. on Thursday, 20th July, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

W. L. MACINDOE, Esq.,
Town Clerk's Office,
Kirkcaldy.
July, 1922. U 705

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification, will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.

SPECIFICATION No. 261:—
STRAIN AND PIN TYPE INSULATORS.

CHARGE:—
£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawing complete. These charges will be returned on receipt of a *bona fide* tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each.

PRELIMINARY DEPOSIT:—
A Preliminary Deposit of £100 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than Noon, 16th September, 1922:—

R. LIDDELOW, Secretary,
STATE ELECTRICITY COMMISSION OF VICTORIA,
MELBOURNE,
Victoria, Australia. U 676

APPOINTMENTS OPEN.

UNIVERSITY OF GLASGOW.

CHAIR OF MINING.

The University Court Pro-

poses to consider the making of an APPOINTMENT to FILL the VACANT CHAIR on 31 July next or later date.

Information regarding the Chair may be obtained on application to the SECRETARY of the University Court, The University, Glasgow.
June, 1922. U 577

LEEDS UNIVERSITY.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING.

The University Council will shortly proceed to the

Appointment of a Demonstra-

tor in Mechanical Engineering. Works experience in addition to good academic qualifications essential. Salary £250. Further particulars may be obtained from THE REGISTRAR, The University, Leeds, by whom applications will be received up to the 24th July. U 650

Wanted, Advertisement and

PUBLICITY EXPERT, to prepare Catalogues, Circulars, Advertisements, Announcements, etc. Steam, Electric and Mining experience desirable.—Applications, stating age, full experience and salary required must be made on sheets written on one side only, in envelopes marked in left hand top corner "A.P.X.," addressed to ROBERT A. HOPKINSON, Chairman and Managing Director, Messrs. J. Hopkinson & Co., Ltd., Makers of Patent Safety Boiler Mountings and Valves, Britannia Works, Huddersfield. U 667

BOARD OF EDUCATION.

APPOINTMENT OF ASSISTANTS AT THE SCIENCE MUSEUM.

The Board of Education invite

Applications for Appointment

as ASSISTANTS on the Higher Technical Staff of the Science Museum. There are two vacancies in this grade.

Applicants must be between the ages of 22 and 26 on the 1st June, 1922, but in exceptional cases applications from persons above the age of 26 on that date will be considered.

Candidates will be expected to have had a sound general training equivalent to that required for a University Honours Degree in Civil Engineering, or Electrical Engineering. Experience of Post Graduate practical work will be regarded as an important qualification.

The commencing salary will be £300 per annum in the case of entrants under 25 years of age and £350 per annum in the case of entrants over that age, together with the usual Civil Service bonus. The persons appointed will be pensionable Civil Servants.

Further particulars of the appointment and Forms of Application may be obtained from the DIRECTOR AND SECRETARY, Science Museum, South Kensington, London, S.W. 7.

Applications should reach the Department not later than 15th August, 1922. U 672

CIVILIAN EDUCATIONAL STAFF—ROYAL AIR FORCE.

Applications are Invited

for VACANT APPOINTMENTS as EDUCATION OFFICERS, Grade III and Grade IV, on the Educational Staffs of the undermentioned establishments:—

Boys' Wing, Royal Air Force, Cranwell, near Sleaford, Lincolnshire.	Grade III
No. 1 School of Technical Training (Boys), Halton, near Wendover, Bucks.	Grade III
Electrical and Wireless School, Flower Down, near Winchester (Airmen and Boys).	Grades III and IV
School of Technical Training (Men), Manston, near Ramsgate.	Grades III and IV
R.A.F. Depot, Uxbridge (Airmen).	Grades III and IV

The salary scales, to which Civil Service Bonus will be added, are given below. These scales are provisional and are now being reconsidered. Allowances up to ten increments of the scale can be made for previous experience and war service. Preference will be given to candidates who have served as commissioned officers in any of the three Services. The principal subjects of instruction are English, Practical Mathematics, Applied Mechanics and Drawing.

Grade III (Graduate)	£150–10–200–15–£350	With current Civil Service bonus, approximately £374–£543.
Grade IV	£110–10–£275	£314–£450.

Applications must be made on A.M. Form 66, which, together with further particulars, can be obtained from the SECRETARY, A.E., Air Ministry, Kingsway, London, W.C. 2. U 671

UNIVERSITY OF CAPE TOWN.

DEPARTMENT OF CIVIL ENGINEERING.

Wanted, by 1st October, or

as soon after as possible, a FIRST GRADE MECHANICAL ASSISTANT in the Civil Engineering laboratory. Applicants must be good mechanics and have had satisfactory workshop experience. The duties of the position are to work and repair the testing and hydraulic equipment in the laboratory, to lay down new plant, to make test specimens and accurate experimental apparatus and, generally, to work under the instructions of the Professor. Experience in turning, fitting and fine instrument work is essential.

Salary £300 a year rising to £480 by annual increments of £25. The appointment is probationary for the first two years. An allowance of £40 will be made for passage money; pension rights are secured under the Government Teachers Superannuation Fund, membership of which is compulsory; six months' leave of absence may be granted after six years service, three months of which will be on full pay.

Applications in triplicate should be sent to the SECRETARY, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, not later than 15th July, 1922. U 676

ENGINEERING.

CHOICE OF A SYSTEM FOR ELECTRIC TRACTION ON MAIN LINE RAILWAYS.

By L. THORMANN, Consulting Engineer to the Bernese Subsidised Railways.

TEN years ago, the question of the most suitable system for electric traction on main line railways appeared to be settled, at least for European conditions. Following the lead of the Imperial Railway Administration, the German States had adopted the 15-cycle, single-phase system; while Switzerland intended to use the same system for the Federal railways, the Bernese Alpine Company having already adopted it. In France, the Cie. du Midi had begun to connect its Pyrenees lines for single-phase working, while Sweden was about to experiment with this system on the Riksgräns Railway.

The war brought railway electrification to a standstill, except in Switzerland. Here the effects of the coal shortage produced an opposite result, and after much delay the Swiss Railway Administration ultimately adopted single-phase traction officially. After the armistice, high coal prices and the desire to reduce fuel consumption called general attention to the question of railway electrification. Even coal-producing countries, like England, and others, like France and Belgium, who in addition were able to draw on Germany, regarded early electrification of large sections of their railways as an important part of their economic reconstruction. With this object in view, French, English, Belgian, Dutch, Swedish, Norwegian, German and Austrian Commissions studied almost simultaneously the more important installations in service or under construction. Of these, the results of the French and English Commissions are best known. These considered that the continuous-current system at 3,000 volts (later reduced at 1,500 volts) would be the best for their countries.

It is not the author's intention to investigate the reasons which led the above-mentioned countries to choose continuous current. To weigh correctly all the factors which have to be taken into consideration is not a simple matter. On the other hand, now that ten years' experience of heavy single-phase traction is available, it may be worth while to examine whether this system has given what was expected of it, and in what points other systems might perhaps be advantageous. For this purpose, technical rather than economical matters will be chiefly considered, though in some cases the two are inseparable.

The Overhead Conductor Voltage.—From a purely technical standpoint, the magnitude of the pressure in the overhead conductor affects the stress on the insulation which has to be used in the lines, rolling-stock and central stations. This affects the safety of working of the system. It is clear that the lower the voltage, the less the insulation difficulties and the easier the construction and maintenance. In this respect, the low pressure of 600 volts to 800 volts used for tramways and suburban railways would be advisable for main-line traction. Further, since accidental contact with this pressure is seldom fatal, the necessary precautions would be much simplified. Unfortunately such a solution becomes economically impossible with main line electrification, owing to the heavy currents it involves. Since higher pressures are necessary, and since with 1,500 volts, contact may be fatal, it is immaterial from the point of view of safety whether this or a higher pressure is used. The problem consequently reduces itself to a solution of the purely technical question of sufficient insulation for the different parts of the installation.

(*a*) *The Overhead Conductor.*—It can be definitely stated that it is not more difficult to obtain a safely-insulated overhead system with 15,000 volts than with one-tenth of this pressure. This is proved by all the single-phase lines at this voltage where carefully selected types of insulators made of sound material have been used. Experience has shown in this connection that installations with single insulation to earth are just as safe in working as those where two separated insulators are used. In both cases failures due to insulation breakdown are extremely rare. Porcelain alone is used as dielectric for this purpose at the present time. The fact that insulation breakdowns occurred in the early stages of working 15,000-volt lines, as in long, wet tunnels on the Loetschberg Railway, can be attributed solely to an imperfect knowledge of the conditions; and the troubles vanished entirely when properly-dimensioned insulators were used.

For further confirmation of the statement that a 15,000-volt line can be regarded as absolutely safe from an insulation standpoint, analogous conditions in power transmission lines have only to be considered. Three-phase distributing networks at 15,000 volts to 16,000 volts are now quite common, and it is only with pressures of 80,000 volts and above that insulation troubles may be expected. It is true that a high-pressure, single-phase overhead conductor requires careful maintenance, and that a specially-trained *personnel* is essential. But this is equally true for installations with lower voltages. The number of employees for this service depends much more on the extent of the sections, and the arrangements for the rapid movement of the staff with their workshop equipment than on the voltage used. On the contrary, it is to be expected that with lower pressures, the amount to do will be greater because of the larger number of conductors entailed by the larger currents. The smaller the number of conductors and the less the weight, the less will be the maintenance work and cost, since in this connection wages far exceed cost of material.

A further point which has to be considered is the possibility of, and the danger in, the case of short circuits. As regards the possibility of short circuits, there is more likelihood with higher pressures, since flash-overs can occur at distances and with dimensions which would be quite safe for lower pressures. An experienced contractor, however, can take suitable precautions against this danger. On the other hand, the harmful effect of a short circuit does not depend on the pressure, but on the amount of energy released at the point of short circuit. The latter is a function of the energy stored in the power station and of the resistance or impedance of the line and apparatus affected. Hence as regards the possibility of limiting the power on short circuit, railways with high conductor pressure may not be the most unfavourable, because these at present work with alternating current, where the effect of impedance may make the short-circuit conditions less severe than with continuous current. Actually, experience has shown that with 15,000-volt, single-phase systems, properly protected by ample, quick-acting, maximum-current cut-outs, it is very rare that serious damage such as destruction of the conductors, occurs on short circuit.

(*b*) *High-tension Rolling-Stock.*—The magnitude of the overhead pressure has much more effect on the locomotives than on the overhead conductors. In the first place, the high pressure must be reduced to the voltage of the driving motors. For commutator motors, such as are used with continuous and single-phase currents, the voltage range is rather narrow; but for three-phase induction motors, there is much greater choice in this respect. The single-phase, neutralised, series motor seldom works with higher pressures than 600 volts to 800 volts, so that a transformer on the locomotive is invariably needed. The continuous-current motor can be built for 1,500 volts per commutator. For reasons of safety, however, a lower commutator pressure is usually preferred, so that it is customary to connect two or more commutators in series. For this reason, the use of continuous current at 3,000 volts—the highest pressure used as yet for continuous-current traction—is based on two motors at 1,500 volts, three motors at 1,000 volts and four motors at 750 volts. Thus with the continuous current system the choice of pressure is very limited, since the installation of a motor generator on the locomotive, to reduce the pressure, is not practicable on account of cost and efficiency.

With the three-phase system, as used on the

Italian State Railways, the induction motors have been built for the line pressure of 3,000 volts, so that transformers on the locomotives are unnecessary. How much higher this could be carried need not be inquired into here, because this system will not be considered further owing to other inherent difficulties associated with it.

Owing to the necessity for a transformer on the locomotive, it would seem that the alternating-current system is inferior to the continuous-current system. As, however, the transformer is of the greatest importance for obtaining speed regulation, it may be questionable whether it should be really regarded as a disadvantage at all. At the outset, various troubles arose through insufficient insulation of the high-tension windings; but these faults have now been remedied. In particular, it has been found that the leading-in coils of the transformers must be very well insulated on account of the excess pressures and travelling waves which occur in railway networks owing to atmospheric effects, switching phenomena or earths. The effects of earths have proved to be very destructive, and the overhead conductor system must be constructed so as to prevent their occurrence as far as possible. As it is not possible to eliminate them entirely, an attempt must be made to lead away the continuous-current charges from the lines. The permanent resistances connected between the overhead conductors and earth used on the Loetschberg Railway appear to have been successful. Since their introduction (made simultaneously with the improvements in the tunnel insulation, and in the insulation of the transformer coils) very few transformer failures have occurred. In this connection, the statistics of failures from 1913 to 1919 in the lines and locomotive transformers of the Loetschberg Railway are of interest:—

Number of failures in	1913 (Six months)	1914	1915	1916	1917	1918	1919
Overhead conductor in the open	30	54	13	12	17	13	11
Overhead conductor in tunnel	180	163	43	13	9	4	8
Locomotive transformer	16	17	6	6	4	1	3

The failures on the overhead installation include troubles caused by birds. All the transformer defects were breakdowns in air-cooled types and the experience gained during the last year, since oil-cooled transformers have been introduced, leads one to expect even better results.

There is very little high-tension apparatus beside the transformer on the locomotive, so that the voltage has but little effect on the safety of working. Usually there is only a high-tension oil switch between the collector and the transformer, which can be built to fulfil requirements and arranged for proper inspection. This switch obviously cannot be dimensioned to cope with the short-circuit energy of the power stations, since there is not enough space available on the locomotive. Such a requirement, however, would go too far, for the possibility of a direct short-circuit of the bare transformer copper to earth is practically out of the question, because even with a coil breakdown there is always more or less contact resistance. This may account for the fact that the relatively small high-tension switches which have been used on single-phase locomotives have proved satisfactory.

Locomotives and Motor Coaches.—From a technical point of view, it can be definitely stated that with the means now available it is possible to build locomotives and motor coaches with all three systems to meet the traction requirements of the heaviest and fastest trains. When the locomotives for a given power driven by continuous, single-phase or three-phase current are compared, it is not possible to discover great differences in their performance. The speed regulation with all three is satisfactory. A greater number of steps are possible with single-phase, but at the expense of the transformer. From the point of view of starting torque, continuous current and three-phase motors are somewhat superior. The three-phase motor further has the advantage that no commutator is needed. Three-phase traction systems are, nevertheless, extremely rare compared with continuous-current systems, so that the commutator has clearly not hindered the development of the latter. The single-phase motor is rather more difficult to handle than its continuous-current competitor, but the progress in recent motor construction is such that the difference is scarcely noticeable.

Regenerative braking, which was originally limited to three-phase traction, has now been developed for both single-phase and continuous-current motors, so that there is no longer any important fundamental difference in this respect. Experience shows that there is not much difference between the efficiencies on the locomotives with the several systems. Theoretically the efficiency of the single-phase motor is somewhat lower than that of the other two, in addition to which there is the transformer loss. These disadvantages, however, are discounted by economical starting and speed control. In comparing efficiencies of systems, care is necessary, because it is not the several parts alone which have to be considered, but the total efficiencies from the generator to the wheel rim.

The possibility of constructing motor coaches for passengers or goods is also of importance from a technical standpoint. Such coaches have been built for all three systems; for example, for the 800-volt three-phase system on the Burgdorf-Thun line, for the 2,400-volt continuous current system on the Chur-Arosa and Nyon-St. Cergues lines, and for the 15,000-volt single-phase system on the Loetschberg line. It is not the magnitude of the overhead pressure, but the limited space for accommodating the equipment which is the chief difficulty, for this space is only about one-half of that in a locomotive of equal weight. With standard gauge it is not possible to accommodate more than 200 h.p. to 250 h.p. per axle on single-phase motor coaches, and about 50 per cent. more than this with continuous or three-phase current. These powers would entail axle loads of about 15 tons to 16 tons, so that the coaches would need a sound permanent way.

The high-tension apparatus and transformer enhance the structural difficulties of single-phase motor coaches, and further reduce the factor of safety. With 3,000-volt, continuous-current coaches, similar structural difficulties are met with, since here also it is hard to accommodate the apparatus and the indispensable auxiliary motor generator for reducing the voltage.

Where, therefore, the traffic conditions demand the extensive use of motor coaches, as in dense urban and suburban traffic, and where longer distances do not occur, it becomes desirable to use a much lower pressure in the overhead conductor, in order to obtain rational conditions for the motor coaches. With continuous current, about 1,500 volts would be the upper limit for motor coaches. For long-distance traffic another solution has to be sought, and if possible one which permits the rolling stock of the long-distance lines to work also on the low-pressure system. If continuous current is used for both local and long-distance lines, this requirement can be most easily satisfied by making the pressure for the latter a multiple of that for the former, so that series-parallel grouping can be adopted. It is more difficult to find a solution when high-pressure single-phase current is used for the long-distance traffic and low-pressure continuous current for the local traffic. Here, probably, the simplest solution is to change locomotives at suitable termini of the low-pressure area. It is, of course, not impossible to build locomotives, &c., capable of working on both systems, but the solution is not simple. If the local, low-pressure, continuous-current network is relatively unimportant, it is better not to attempt to combine the systems, but to replace the local by the long-distance system; which is feasible because suitable motor coaches for high-voltage, single-phase current can be built, as evidenced by the Loetschberg, the Hamburg suburban, the Hague-Scheveningen and the Upper Silesian railways.

Consequently, for the conditions on the European Continent, the question whether motor coaches can be built at greater or less expense is not of serious importance in deciding the system for main line railways. The matter will have to be largely settled by the needs of the long-distance traffic; while the few cases where local services have to be combined must be considered on their respective merits.

Turning more to the economic side: in addition to efficiency, the cost of manufacture of locomotives, &c., for the several systems is of interest. For this purpose weight alone comes into consideration, either for the electric equipment or for the whole vehicle. This assumption is nearly true; for the cost per unit weight is practically unaffected by the system. Consequently a comparison of the weights affords a good insight into the relative costs. At the same time the motor capacity and speed must be taken into account when locomotives for similar duty are compared. The motor speed particularly has considerable influence, and it would be quite wrong to make a direct comparison between a slow-speed goods locomotive and an express locomotive. As the speed increases, the weight per unit output decreases owing to the better utilisation of the driving motors at higher speeds. The same holds in general for increasing outputs, because much of the auxiliary equipment does not increase as the power.

As a basis of comparison, either the power in horse-power per kilogramme, or the reciprocal, the weight per horse-power, with either hourly or continuous rating, can be taken. Many such comparisons of existing machines have been published, in some of which the influence of the speed has been considered. From these it is seen that up to 3,000 volts, for which no transformer is needed, three-phase locomotives are the lightest of all. With this system, a weight of 30 kg. to 40 kg. per horse-power is necessary, based on one hour's rating. For single-phase up to 15,000 volts and continuous current up to 3,000 volts, the weights of recent, large locomotives vary from 42 kg. to 60 kg. per horse-power. For similar conditions, European single-phase locomotives for 15 cycles to $16\frac{2}{3}$ cycles are usually somewhat lighter than the American 3,000-volt, continuous-current locomotives. In any case it can be taken as certain that neither high-voltage continuous-current equipment nor locomotives are lighter than single-phase constructions, despite the apparent complications of the latter introduced by the transformer; so that there cannot be very much difference in the manufacturing costs of the two types.

Another question is the cost of upkeep of locomotives of the three systems, in so far as differences due to the nature of the system arise. Much has been published on this matter, but it is none the less difficult to draw satisfactory conclusions. In order to obtain a fair comparison, it would be necessary to have at the same place under the same management two services of the different systems working for several years under similar traffic and loading conditions—an almost unattainable ideal. To judge from annual reports or from the number of men employed in a repair shop is not sufficient. The differences in manufacture, the excellence in workmanship, the care in maintenance, the nature of the traffic requirements, are all important factors in estimating the average costs of upkeep, not to mention the differences in costs of material and labour or in the methods of keeping accounts.

The question can be examined in another way, by assuming that a certain relation exists between the weight of a locomotive and its cost of upkeep; the lighter locomotive needing the lower cost because of the fewer parts to keep in repair. Given similar conditions, there appears to be no justifiable objection to this method; which would lead to the result that the upkeep of three-phase locomotives is the lowest, while that of high-voltage, single-phase and continuous-current locomotives would be about equal. Advocates of the continuous-current system are often of the opinion that the upkeep of single-phase must be more costly than that of continuous-current equipment, because single-phase motors are usually heavier than corresponding continuous-current motors and are more difficult to construct, while in addition there is the upkeep of the transformer and the high-tension gear. Theoretically this appears to be correct. In practice, however, it has been proved that it is possible to manufacture single-phase equipments, the parts of which give

as little trouble as the corresponding parts of the other system. In this connection the following figures are of interest—they are the average results of seven years' working of the Loetschberg Railway.

	Locomotive Kilometres.
Wear of 2½ mm. off motor commutator	350,000
Life of a carbon brush	20,000
Life of a pinion	400,000
Life of a renewable strip on bow collector	15,000

For the total cost of maintaining the electric locomotives and of the steam locomotives belonging to the same company—the Bernese Alpine Railways—the figures for 1915–19 are :—

Year.	Electric Locomotives.			Steam Locomotives.		
	Loco.-Km.	Cost of Upkeep. Total in Francs.	Cost of Upkeep. Centimes per Loco.-Km.	Loco.-Km.	Cost of Upkeep. Total in Francs.	Cost of Upkeep. Centimes per Loco.-Km.
1915	584,000	88,000	15·2	877,000	189,000	21·6
1916	502,000	119,000	23·8	898,000	223,000	24·8
1917	508,000	153,000	30·0	787,000	227,000	28·8
1918	448,000	210,000	47·0	591,000	315,000	53·2
1919	587,000	386,000	65·6	617,000	396,000	64·0

Apart from the increasing costs during the war, these figures show that the cost of maintenance of the electric locomotives is much lower than that of the steam locomotives, for while the steam locomotives give draw-bar pulls of 6,000 kg. to 8,000 kg., or 700 h.p. to 1,000 h.p., the electric locomotives give a draw-bar pull of 13,000 kg. or 2,500 h.p. When it is remembered that the upkeep costs for the mechanical part and for the auxiliaries, such as the equipment for brakes and lighting, form a large part of the total and are independent of the nature of the system of current employed, it is not likely that much lower figures would be obtained with continuous current. It should also be pointed out that the Loetschberg Railway was an early electrification, and since then considerable improvements in the several parts have been introduced, as is seen on the recent locomotives supplied to the Bernese and the Swiss Federal Railways.

Experience shows that the maintenance costs of the locomotives of a well-managed, high-voltage single-phase railway should be about the same as those of a high-tension, continuous-current railway working under similar conditions. If in the one system there is high-voltage apparatus to be kept in repair, in the other there is a similar amount of apparatus for low-tension but for much larger currents; and the cost does not depend so much on the insulation as on wages and material.

(To be continued.)

ECONOMIC CONDITIONS IN CHILE.

AMONG the many world markets opened by British enterprise and with British capital, Chile has a trade history three-quarters of a century old. The earliest sea transport scheme was inaugurated in 1840 by the Pacific Steam Navigation Company, and they have maintained their supremacy as carriers until the present day. Foreign traders soon followed, hoping to share in the wealth produced in this land rich in mineral resources. How far Britain has maintained the position achieved by her early endeavours we can judge from the "Report on the Industrial and Economic Situation in Chile," by W. F. V. Scott, the Commercial Secretary to H.M. Legation at Santiago, which was recently published by the Department of Overseas Trade. A few years before the European war, Germany had become a strong competitor in the Chilian markets, and the United States were making continual progress. When war broke out everything favoured the Americans: German interests had ceased and British endeavours were reduced. The Americans obtained all the former German business and a part of the British. At the end of the war keen competition was re-established, and in 1920 Britain regained her position of supremacy as the first importer to the Republic, although her purchases of Chilian products and raw materials were only one-half of the pre-war standard. American imports, which were valued at 14,389,092*l.* in 1919, were reduced by 3,869,092*l.* in 1920, while the British Empire imports showed an increase of 2,849,104*l.* on a total, in 1919, of 7,734,600*l.* A considerable increase of German trade was reported in 1920, when the total imports reached 1,580,000*l.*, and it is from this competition the British manufacturer has most to fear.

The year 1920 was one of great prosperity for Chile, and in spite of the depression which set in during the second half of the year, her foreign trade reached its highest value. The nitrate production on which the prosperity of the country largely depends, showed enormous profits, in some cases equal to the capital invested. When the European markets, already overstocked, became glutted in 1921, the activity of the Nitrate Oficinas had to be reduced and eventually the works had to be shut down, which event was marked by the rioting of the infuriated workmen, in the course of which the manager and some others were killed. Political upheavals and labour unrest contributed largely to the trading difficulties, and with the nitrate market in its present condition it is difficult to see how the situation can be improved during the year.

The trade in iron and steel manufactures is at a standstill, except in rails and railway material, of which large quantities are being acquired by the State railways. Tenders for large quantities of railway materials were called for during 1921 and contracts for all were placed in the United States, except a contract for 300,000*l.*, covering 12,000 tons of steel rails at 9*l.* 3*s.* per ton, and a quantity of cars, which went to Germany. The Baldwin Locomotive Company supplied during 1921 ten metre-gauge locomotives of 103 tons weight at 11,300*l.* each and 20 broad-gauge locomotives of 135 tons were supplied by the American Locomotive Sales Corporation at 13,626*l.* each. A large electrification scheme is being carried out by the Westinghouse Electric International Company on the State railway between Valparaiso and Santiago. Several small lines have been constructed, and some are now in use. The most important future work is the construction of a new line between Valparaiso and Santiago passing through Casablanca and Curacavi with a branch to Talagante. The line is to be worked by steam or electricity, and the proposition is being investigated by contractors, including some British firms. The construction of two Transandine railways is proposed. For the southern one, the Lonquimay Transandine, which seems to be the more popular proposal, the engineering staff was appointed late in 1921. It will traverse the Bio Bio Valley with a great expanse of agricultural land, large deposits of unworked oil shales and extensive forests of Araucaria pine, suitable for paper pulp making. The Chilian Government concluded a contract at the end of 1921, with the Siemens-Schukert Company to erect 11 radio telegraph stations, which will be worked on the Telefunken system.

The copper exported during 1920 amounted to 110,000 tons, of which only 26,000 tons were produced that year owing to the failure of the oil companies to supply fuel. The exports during 1921 showed a marked falling-off, and the mines are now mostly closed owing to the slump in the copper market. Plant to work low grade material and transporter appliances will be required by many of the concerns once work is resumed. American and German concerns are working the iron ore deposits. Chilian coal is a poor substance from the standpoint of coke production, and so far this has prevented the development of iron and steel works. Considerable activity is shown in the Chilian oilfields, and the coast is now well supplied with oil tank equipment for the storage of fuel and Diesel oils. Manufacturers who are interested in Chilian business will find a lot of valuable information on trading conditions, the methods used by the Germans and Americans in their endeavours to get further into these markets, as well as trade statistical tables, in this well-compiled report.

CREDITS FOR PUBLIC WORKS IN MOROCCO.—H.M. Agent and Consul-General at Tangier states that a Bill has been read in the Spanish Parliament by the Minister of Finance, which authorises a supplementary credit of about 60,000,000 pesetas for public works in the Spanish Zone of Morocco. Of this sum it is proposed to allocate 25,500,000 pesetas to the Tetuan-Alcazar Railway.

THE WHITE STAR LINER "MAJESTIC."

Now that the pre-war international rivalry for the possession of the largest and fastest vessels for the passenger traffic of the North Atlantic has been considerably modified by the relegation of Germany to a position of comparative unimportance among the maritime nations of the world, and also on account of changed economic conditions in the shipping industry, it is highly improbable that the position of the White Star liner Majestic, as the world's largest passenger steamer will be challenged for many years to come. This is the more unlikely in that the North Atlantic route, which is the only one upon which such vessels are economically possible, seems now to be supplied with large and luxurious passenger liners in sufficient numbers to meet all requirements in the immediate future.

As mentioned in a brief reference to the vessel which appeared on page 597 of our last volume, just prior to her maiden voyage from Southampton to New York, *via* Cherbourg, the Majestic, which was originally named Bismarck, was built by Messrs. Blohm and Voss of Hamburg for the Hamburg-Amerika Line, and was launched on June 20, 1914. Owing to the outbreak of hostilities shortly afterwards, work on the vessel was suspended during the war period, but she was afterwards completed and acquired by the White Star Line from the Reparations Commission. We have already given some general particulars of the vessel in the short article above referred to, but it will be convenient to repeat these here in order to render the fuller account we are now able to publish more complete. The overall length of the Majestic is 956 ft., the length between perpendiculars 912 ft., the breadth 100 ft., while the depth from boat deck to keel is 102 ft. and the moulded depth 64 ft. The gross displacement is about 56,000 tons and the displacement tonnage, when fully loaded, 64,000.

The general appearance of the vessel is well shown in Fig. 1, on page 4, which is reproduced from a photograph of the vessel taken on her arrival at Southampton from Hamburg in April last. The arrangement of the decks, of which there are 11 in all, will best be followed from an inspection of the longitudinal section of the vessel reproduced in Fig. 2, on Plate II; this figure also shows the positions of the watertight bulkheads which are indicated by thick lines and which serve to divide the vessel transversely into 14 compartments. It will also be seen from the longitudinal section that the boiler uptakes do not lead directly into the funnels through the central part of the ship. Actually there are two uptakes, one on each side of the centre line of the vessel, as shown in the deck plans, Figs. 6 to 11, on Plates II and V, to each of the two forward funnels and each pair of uptakes combines at the base of the funnel above the level of the boat deck. The after funnel, it should be mentioned, is not used for flue gases, but serves for ventilation purposes. The elimination of the large uptakes from the central part of the ship, of course, materially assists in the design of the architectural features of the public rooms.

Plans of the deck houses, of the boat deck (Deck A), and of the promenade deck (Deck B), are reproduced in Figs. 3 to 6, on page 5, while plans of the other decks, lettered C to K consecutively (except I), and of the tank top, are given in Figs. 6 to 14, on Plates II and V. The first-class smoking room, a view of the interior of which is reproduced in Fig. 22, on Plate VI, is situated on the boat deck forward, as shown in the plan Fig. 4, on page 5. It is finished in dark wood with a handsome panelled ceiling and has a large open fireplace at the after end. This apartment is particularly well situated for observation purposes and, having plate glass windows on three sides, is an exceptionally light and attractive room.

Referring now to the plan of the promenade deck, Fig. 5, it will be seen that the public rooms on this deck are surrounded by a promenading space extending along on both sides and continued across the forward part of the deck. From the view of the promenade deck reproduced in Fig. 19, on Plate VI, it will be seen that the space is enclosed with sliding plate glass windows, so that it can be used with comfort in all weathers. The view, Fig. 20, on Plate VI, of the forward or

THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

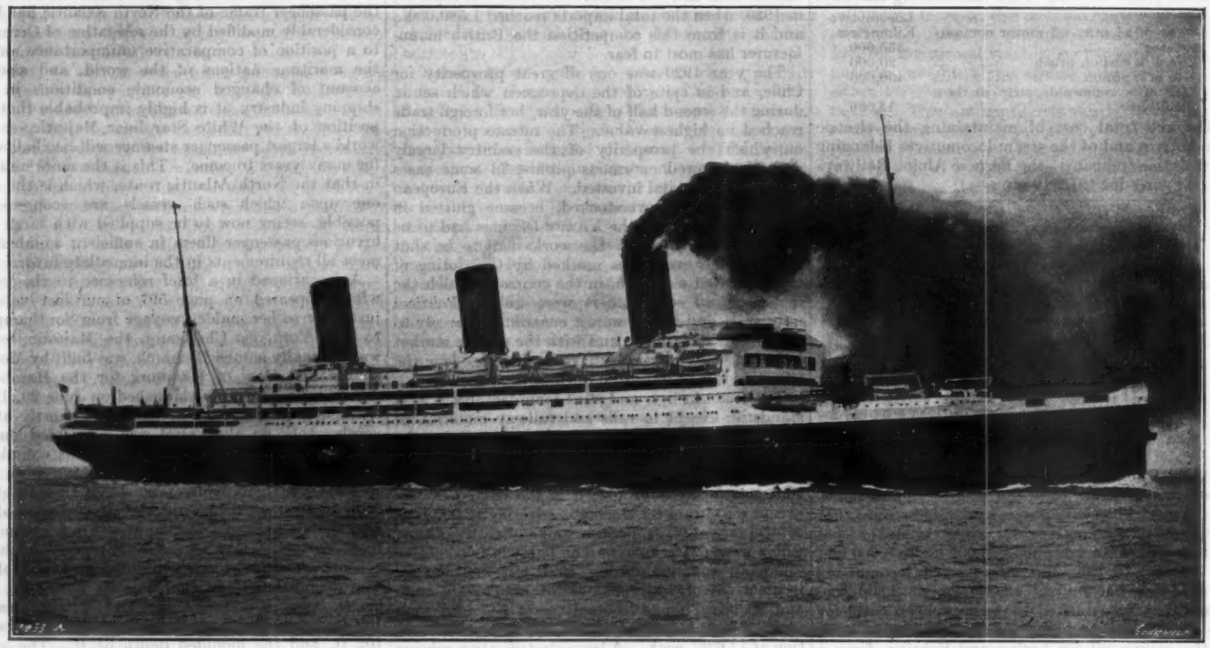


FIG. 1. THE SHIP APPROACHING SOUTHAMPTON FROM HAMBURG.

athwartship portion, which is known as the observation deck, gives a good idea of the width of the vessel.

The entrance to the first-class accommodation is situated on A deck just forward of the central funnel. The staircase leading from this to the vestibule on the promenade deck is illustrated in Fig. 21, on Plate VI. Forward of the vestibule is the lounge, which is an exceptionally large and lofty apartment, 26 ft. high, extending upwards through the boat deck and being roofed in by a handsome glass dome. A view of the entrance to the lounge taken from the interior is given in Fig. 16, on Plate III. The walls are finished in wood panels between carved pilasters, and tall well-proportioned windows are arranged along each side. A large stage for concerts is provided forward, and on each side of this doors open into passages leading to the reading and writing room, which is situated right forward. A feature of this apartment, which we illustrate in Fig. 18, on Plate IV, is the shaded lights mounted on fluted columns fixed to the floor, as shown in our illustration.

On the same deck aft of the vestibule, is situated the palm court, the entrance to which is just visible on the left in Fig. 21, on Plate VI. The palm court, a view of one side of which is given in Fig. 15, on Plate I, forms with the restaurant aft of it, a single steel house, the maximum height of which is 23 ft. The floor of the restaurant is, however, at a higher level than that of the palm court, and the short staircase leading up to the former can be seen in Fig. 15. A card room is provided at the extreme after end of the promenade deck, as shown in the plan, Fig. 5, on page 5. The dining saloon is situated on F deck amidships, as shown in the plan Fig. 9, on Plate V, and a view of one corner of it looking forward is reproduced in Fig. 17, on Plate IV. The saloon, which has seating accommodation for 678 persons, is exceptionally lofty, the central portion having a height of 31 ft. It is covered by a domed and painted ceiling supported by Ionic columns at the sides and ends. Access to the saloon is obtained from the main staircase at the forward end, where two passenger lifts are also provided. Another staircase at the after end of the palm court leads down from the restaurant on the promenade deck as shown in Fig. 5.

The gallery surrounding the swimming bath, which forms another attractive feature of the first class accommodation, is also on the saloon deck level and is reached from the main staircase, as will be clear from an inspection of the deck plan Fig. 9, on Plate V. The dressing rooms for swimmers are on the deck below, and the bath itself extends down to H deck. On either side of the swimming bath are the Frahm anti-rolling tanks with which the vessel is fitted.

Accommodation for some 4,000 passengers is provided in the three classes, about 1,000 of the number being first class. Most of the first-class staterooms are situated on decks C, D, E and F, and there are some exceptionally elaborate private suites on C deck. Second-class passengers, for which accommodation for 545 is provided, are carried aft of the first-class accommodation in staterooms and cabins having two, three or four berths. The second-class dining saloon is on F deck, and forward of the saloon is the main staircase and electric lift for passengers of this class. A smoking room, lounge and ample promenading space are also provided for second-class passengers. Of the third-class passengers, 850 are accommodated in two, three and four-berth cabins, on four decks aft of the second-class part, and they have smoking and ladies' rooms, as well as extensive promenade space. The third-class dining saloon in this part of the ship is situated on E deck. Additional third-class accommodation of a similar character is provided for 1,542 passengers in the forward part of the vessel, where a separate dining saloon and other public rooms for this class are also situated. The arrangement of the accommodation for all classes of passengers can easily be followed by examining the longitudinal section and deck plans of the vessel reproduced on Plates II and V.

With regard to the propulsion of the vessel it is interesting to note that the most economical form was arrived at after extensive research carried out in two experimental tanks using five separate models. In the form finally selected, a saving of 17,000 s.h.p. was effected as compared with the first form tested, the saving being due to alterations in the after part bringing the stern more to the cruiser shape. A considerable increase in the stability of the ship also resulted from these tank experiments.

The vessel is propelled by quadruple screws driven by turbines of the Parsons type, with an astern turbine on each shaft. The four turbines normally work in triple combination, steam entering the high pressure turbine on the port centre shaft, flowing thence to the intermediate pressure turbine on the starboard centre shaft, and then dividing equally between the low pressure turbines on the wing shafts, whence it finally exhausts to the condensers; other combinations are, however, possible. The turbines, which develop about 66,000 s.h.p. when running at 180 r.p.m., are arranged in two engine rooms separated by a watertight bulkhead as shown in the plan of the tank top, Fig. 14, on Plate V. The high-pressure and intermediate-pressure turbines are situated in the forward room and the two low-pressure turbines in the after room. It may be of interest to mention that the weight of one of the low-pressure turbines amounts to 375 tons.

Steam is supplied by 48 water-tube boilers of the Yarrow-Normand type, arranged in four boiler rooms, each containing 12 boilers, as shown in the plan, Fig. 14. The aggregate heating surface is 220,000 sq. ft. and the working pressure of 17·9 atmospheres (260 lb. per square inch) is comparatively high in order to allow for losses in the main steam pipes, which are about 300 ft. in length. The boilers are fired with oil fuel on the White system, five burners being fitted to each boiler so that the total number of burners used is 240. Oil fuel is carried in bunkers on each side of the boiler rooms, in a cross bunker forward, and also in double-bottom tanks. The total oil fuel capacity is approximately 9,000 tons, and the consumption on one voyage is about 5,700 tons. We intend to deal more fully with the oil-fuel installation in a later issue, but we may remark that, in general, it is similar to those fitted on the White Star liner Olympic and the Cunard liner Aquitania, which were fully described on page 23 of our 110th volume.

The auxiliary machinery, which is, of course, on a scale proportional to that of the propelling machinery, calls for no particular comment, but it may be mentioned that the forced draught fans, of which there are four, draw warm air from the engine rooms and deliver it through two main trunks 45 sq. ft. in area, arranged along the sides of the boiler rooms, the air being distributed through numerous

THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

Fig. 3.

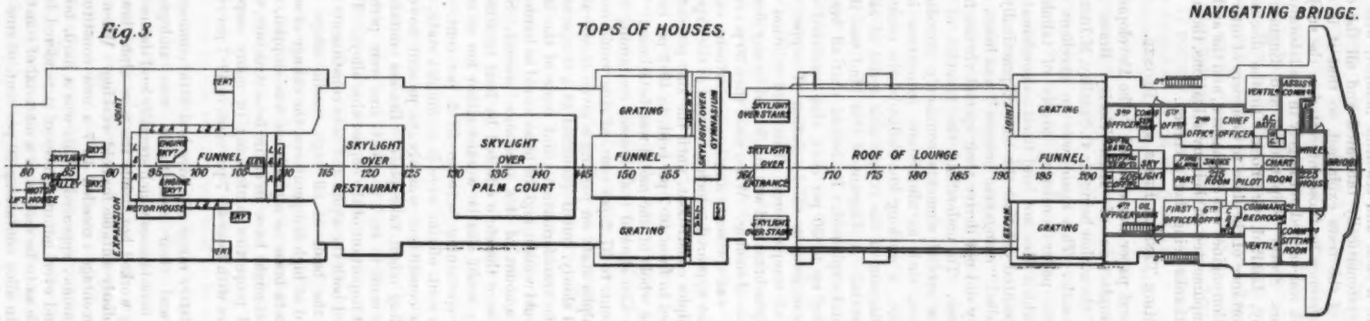


Fig. 4.

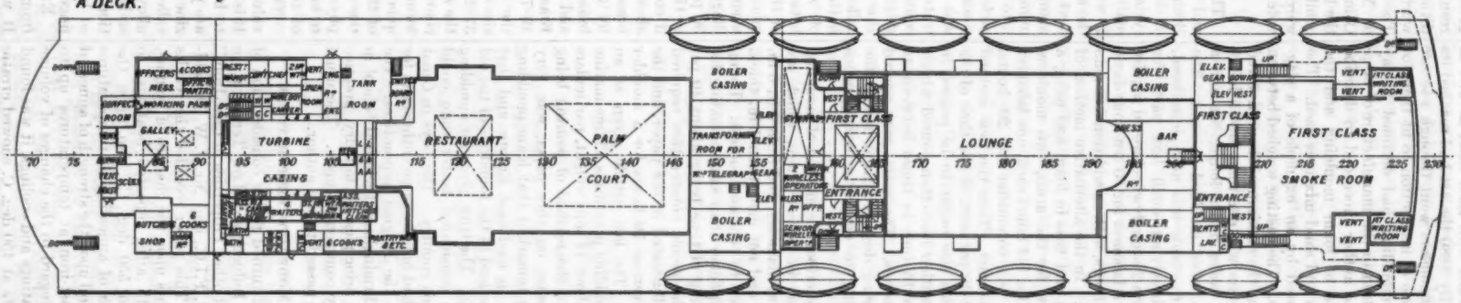
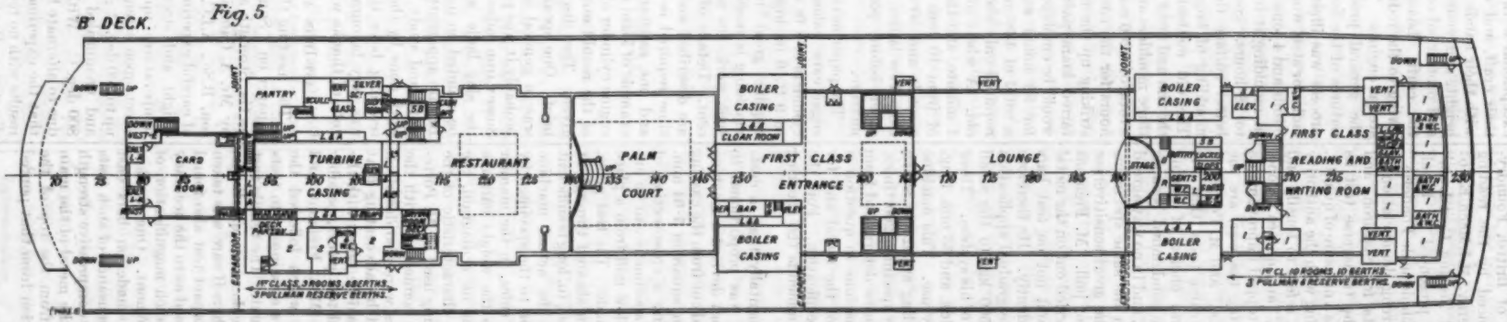


Fig. 5.



smaller branches terminating at the furnace fronts. A separate installation is provided for the ventilation of the boiler rooms, and, for the engine rooms, two steam-driven ventilating fans are installed. The trunks from these fans are carried up the engine room hatch and terminate at the base of the after funnel at a height of 136 ft. above the starting platform. A very complete and carefully considered installation for the ventilation of the passenger accommodation of the ship is also provided. The heating of the accommodation is affected by steam, but all first-class staterooms are electrically heated also. Electrical energy is supplied by five turbo-generators, each developing 288 kw. at 115 volts. The current is distributed from a main switchboard 22 ft. in length and 8 ft. in height, to which 32 feeders are connected. Of these feeders, which have a total sectional area of about 23 sq. in., equivalent to a carrying capacity of 2,850 kw., 22 are for power purposes, 6 for lighting and 4 for heating circuits. The power feeders supply 232 motors with an aggregate horse-power of 1,846, and of these 112, totalling 1,200 h.p., are for ventilation purposes. For turning the turbines and lifting the casings, 8 motors with a total horse-power of 198, are installed, and 12 motors of about 20 h.p. each are used in connection with the life-boat installation. An emergency generating set, driven by an 80-h.p. Diesel engine, and situated on E deck just aft of the engine-room casing, is also provided. This set supplies the emergency lamps distributed throughout the ship, as well as the boat-lowering gear, navigating and signalling appliances and the emergency wireless installation.

In conclusion, we may mention that on the return journey from New York to Southampton after her outward maiden voyage, the Majestic took departure from the Ambrose Channel Light vessel at 2.25 p.m. English summer time on June 17, and arrived at Eddystone Light at 4.7 a.m. G.M.T. on June 23. The total distance between these two points is 3,139 sea miles, and the time taken viz., 5 days 9 hours 42 minutes, gives an average speed of 24·2 knots. This is certainly an excellent performance, but there is little doubt that it will be improved upon in subsequent voyages.

THE INSTITUTION OF BRITISH FOUNDRYMEN.

(*Concluded from page* 822 *of vol. cxiii.*)

THE TESTING OF CAST-IRON.

THE second day's proceedings of the annual conference of the Institution of British Foundrymen at Birmingham commenced by the reading of a paper by M. E. V. Ronceray, M.I.Mech.E., of Paris, on "New Methods of Testing Cast-Iron," the paper in question being presented on behalf of the French "Association Technique de Fonderie." The paper was in effect a strong denunciation of both impact and tensile tests for cast-iron, and a plea for the adoption of the transverse test as recommended by M. Frémont as a measure of quality. The author, presumably speaking with the authority of the association referred to, refers to tensile and impact tests as "stupid tests," and quotes Colonel Prache as saying "What has stopped improvements being made in semi-steel during the war, are the tests imposed by the War Office," and M. Portevin, as remarking, concerning the same tests, that "it was difficult to make a worse choice of testing methods." Impact tests were condemned because their results were inconsistent, and in no way agreed with transverse tests made on the same specimens and tensile tests because of the great sensitiveness of cast-iron to any obliquity of pull. M. Frémont decided that tests should be carried out on the metal of the castings themselves, and not on test bars either cast on, or cast independently. He therefore designed a machine to give the gradual application of transverse loads up to 1,500 kg. to the small test-pieces which are a feature of his system. These are 10 mm. wide by 8 mm. thick, and 35 mm. long, for the machine for laboratory use. This machine is fitted with a graphic recording apparatus which magnifies the deflection of the specimen 200 times. The coefficient of elasticity can be determined from the deflection record. The machine in question is recommended for the study of the metal and for tests for conformity to specification. For the inspection of castings he recommends the shearing test.

Having determined experimentally that in cast-iron, the shearing resistance was proportional to the tensile strength, M. Frémont devised a machine for testing small pieces of metal cut from the casting itself. These were either 5 mm. square or 5·64 mm. diameter, in both cases having a cross-section of 25 sq. mm. area. The round specimens can be cut by a trepanning drill, or a hollow mill from a place where a bolt hole has to be made. The test piece, either square or round, is then sheared through at places 0·125 in. apart. A piece ¾ in. long is sufficient for four determinations. In the actual machine the shearing knife is pressed on to the specimen by a lever along which a weight rides, in the manner of a steel yard. Attached to the weight carriage is a pencil which draws a line on a diagram, the slope of which designates the characteristic of the metal. Other methods of testing used by M. Portevin in France, particularly in connection with the quality of semi-steel projectiles were also described by the author, who concluded by advocating that some international action should be taken with the idea of standardising tests and test pieces, possibly on the lines suggested by MM. Frémont and Portevin. In the discussion which followed the paper, the divergency of views existing as to tests upon cast-iron was quite evident. The tensile test was condemned by some speakers as unreliable, but considered valuable by others if care was taken to get a straight pull. The impact test also found support, and doubt was expressed as to the accuracy of a method which involved such magnification of the results as that of M. Frémont. One speaker referred to acceptance tests made on bars cast separately and said that in thousands of such tests he had never known the same compressive strength to be shown as was found in the metal of the main casting. The metal poured from the top of the ladle had a different composition from that poured from the bottom.

LOAM MOULDING IN BELGIUM.

The next paper to be considered was one by M. J. Varlet, of Liége, entitled "History of Loam Moulding in the Province of Liége." According to the author, loam-moulding was started in Belgium in 1846 by the enterprise of a working pattern-maker. It was not, however, until 1870 that it became generally adopted, and large foundries employed the method for making engine cylinders, condensers, &c. The loam moulders were then exceptional workmen who took an artist's pride in their craft, and worked with their head as well as with their hands. By 1880 the art had reached its height, and young moulders went through a severe and protracted course of instruction to fit them for the craft. Loam moulding had declined to-day owing to the reduction in the manufacture of large steam engines. The author proceeded to describe the general process of loam moulding and the natures of the loam and sand mixtures used. The process was illustrated by an example of a slag-ladle for steel works. The casting weighed between 3 tons and 4 tons, and the maximum labour involved in moulding it in loam was one man for 15 hours to 18 hours. Such ladles had a longer life and a better surface than when moulded in sand. The moulding of large flywheels was next considered. The old method, involving small box parts for the rim and arms for a 20-ton flywheel would require three moulders and a labourer for 30 ten-hour days, a total of 1,200 man-hours, with an additional 80 man hours for the cores. In the alternative method of striking up the rim and boss in loam and using a tarred loam pattern for the arms, two moulders would be employed for 144 hours each, one labourer for 80 hours and one coremaker for 20 hours, a total of 488 man-hours. Thus the new method required only about 40 per cent. of the time of the old. A wheel of this size ought to be poured in 1 minute, and the author had often poured wheels of from 10 tons to 15 tons in times between 44 seconds and 50 seconds. The metal was poured from two ladles, being decanted from one to the other before pouring to ensure a homogeneous mixture.

The paper next describes the method of moulding sugar cane calendars in loam. These, which are cylinders of 8 ft. 6 in. diameter, and from 6 ft. 6 in. to 9 ft. 6 in. high, and not more than 1 in. thick, require great care to ensure success. Loam-moulding is much quicker than sand-moulding for such work, the saving of time being about 40 per cent. Details of the mould construction required are described and illustrated in the paper, and the time required is given as 70 hours for a moulder and one assistant. The last article given as an example of loam moulding practice is a large marine engine cylinder of about 12 tons weight, particulars of the mould and of the method of pouring being given. The discussion on this paper was very brief. One speaker remarked that loam moulding was in general use in mediæval Europe and that probably it was practised in the foundries of the old Sussex iron industry. The time given for moulding the slag ladle was considered better than could be counted on in this country. The boys in Great Britain apparently had not the same enthusiasm for work and study as the Belgian apprentices. The work done by the Birmingham Technical School in teaching boys the principles of foundry practice was very favourably commented upon. The usual vote of thanks was passed to the author.

CAST-IRON AT MODERATE TEMPERATURES.

The meeting then turned to the consideration of a paper on "Some Influences of Low Temperature on the Strength and other Properties of Cast-Iron," by Mr. A. Campion, F.I.C., and Mr. J. W. Donaldson, B.Sc., A.I.C. This paper recorded the results of careful experiments upon the changes of volume, weight and strength after repeated heatings to temperatures up to 550 deg. C., also upon the effect upon strength of annealing at temperatures up to 700 deg. C.; and upon the strength of annealed and unannealed cast-iron at temperatures up to 800 deg. C. With regard to the changes of volume due to alternate heatings and coolings, it was found that the experiments at 450 deg. C. showed erratic results with no tendency to change in any particular direction. Heating up to 550 deg. C. caused a continued growth, and after 55 heatings constancy was not in sight, and the strength of the iron, moreover, was seriously reduced by the treatment. The tests on the tensile strength of cast-iron at various temperatures brought out the fact that there was a well-defined maximum strength at a temperature of about 400 deg. C., and after this the strength fell very rapidly. Both material "as cast" and annealed specimens showed much the same characteristics, though with annealed iron the variations of strength were smaller. The paper was put together in a clear and scientific manner, with the results systematically tabulated and all the conditions of the tests explained, so that it is well worth reference by those interested in the subject. The work was carried out largely in the laboratories of Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock. In the discussion the importance of the data to designers of internal-combustion engines was emphasised, and the authors were complimented on their investigations, the usual vote of thanks being then accorded.

HIGH TENSILE BRASS AND BRONZE.

The next paper was entitled "The Development and manufacture of High-Velocity Brass and Bronze," the author being Mr. O. Smalley, M.Inst.M., of Newcastle. This again was an excellent and systematic paper consisting largely of tabulated matter which does not lend itself to condensation. It was pointed out that the base of practically all the so-called "manganese bronzes" was brass, and that they did not derive their special virtues from manganese. To understand the function of the numerous special elements commonly introduced into brass, such as aluminium, manganese iron, nickel, &c., a working knowledge of the constitutional diagram of the copper-zinc series of alloys was essential. A diagram of this kind was illustrated and explained. It showed that all brasses containing up to 30 per cent. zinc consisted of a single homogeneous solid solution of copper and zinc at all temperatures. This solid solution was called alpha-brass and was unaffected by any change in the rate of cooling. When more than 30 per cent. of zinc was present another constituent called beta-brass appeared, which increased at the expense of the alpha constituent, until the zinc percentage amounted to from 46·7 per cent. to 49·2 per cent., when the whole of the metal was beta-brass. The diagram also showed that brasses containing from 30 per cent. to 37·2 per cent. of zinc would revert to the alpha state on passing a given temperature if cooled slowly, but if quenched at a temperature above the transformation point some of the beta-brass would remain, and the brass would be hardened by the amount of this substance present. Such brasses were therefore effected by heat treatment, and they could also be worked either hot or cold. Brasses containing between 37·2 per cent. and 49·7 per cent. of zinc were in a complex state, and the beta constituent was always present however the cooling might take place. Brasses containing 37·2 per cent. to 46·7 per cent. zinc were perhaps the most important of the copper zinc alloys. They contained both the alpha and beta constituents and formed the basis of all high tensile alloys. If quenched at high temperatures, the change of some of the beta-brass to alpha-brass was stopped, and the metal might have an entire beta structure, with physical properties conforming in many respects to brasses with from 46·7 per cent. to 49·7 per cent. of zinc.

This latter range of alloys had little commercial value, and their constitution was ambiguous. It is the beta-brasses which specially lend themselves to being worked hot, while the pure alpha brasses are peculiarly suitable for cold working. When the zinc percentage exceeded 49·7 a new constituent, called gamme, appeared. This was a hard, brittle alloy, and even minute traces of it rendered brass so brittle as to be useless as a material of construction. An alloy containing 60 per cent. of zinc was so brittle that it might be crumbled between the fingers.

Experiments were made on brasses containing from 1 per cent. to 5·8 per cent. of aluminium. It was found in general that each 1 per cent. of aluminium had the same effect on the physical properties of brass as 5·6 per cent. of zinc. Taking copper, zinc and aluminium in the order stated, a 70 : 26·5 : 3·5 alloy had the characteristics of ordinary Muntz metal; a 70 : 24·2 : 5·8 alloy was similar to a 53 : 47 or all-beta brass; and a

59 : 39·67 : 1·33 alloy appeared equivalent either to a 70 : 24·4 : 5·8 alloy or to a 53 : 47 brass, and so on. Small quantities of aluminium had a remarkable effect in increasing the yield-point and strength of both 70 : 30 brass and 59 : 41 brass, when cast in chills, but there was a corresponding fall in ductility and in shock-resisting properties. A 69·79 : 26·67 : 3·4 alloy as cast, had a yield-point of 13·6 tons, a breaking stress of 29·30 tons, an elongation of 26 per cent. on 2 in., and a reduction of area of 27·6 per cent. It was structurally equivalent to a 59 : 41 brass, but had the strength of mild steel and a remarkable resistance to dynamic stress. This, and other alloys in which the zinc had been replaced by aluminium up to 5·9 per cent., showed an all round improvement in mechanical qualities after forging, a tensile stress of 38·6 tons with 17 per cent. elongation in 2 in. being recorded for a forged 69·42 : 24·68 : 5·90 alloy.

Manganese was introduced into brass, either by means of the use of 80 per cent. ferro-manganese or 30 per cent. cupro-manganese. The use of ferro-manganese involved a high melting temperature and the risk of extremely hard spots in the finished product. Similar hard spots might also occur when cupro-manganese was employed, unless the casting was very carefully supervised. Considered as a replacing element, 1 per cent. of manganese was equivalent to 0·8 per cent. of zinc, but the real function of manganese lay in other directions. Manganese up to 2 per cent. appeared to have little influence on the tensile strength although both strength and ductility were slightly improved. The alloys tested showed very similar characteristics to ordinary 59 : 41 brass, and the manganese did not appear to affect the hot working properties.

The chief function of tin in brass was to increase its resistance to corrosion. In complex brasses the tin should not exceed 0·7 per cent., and in naval brass the limit was 1 per cent. The amount of tin which brass would take into solid solution depended on the zinc content. The lower the latter the more the tin which would be taken up; an 80 : 20 brass would absorb 5 per cent., while a 70 : 30 brass would absorb barely 1 per cent. Iron could be introduced into brass in the form of either a copper-iron or zinc-iron alloy. The outstanding feature of the influence of small quantities of iron on 70 : 30 brass was the refining effect on the texture of the metal and the improved homogeneity. For ordinary workshop practice 0·35 per cent. of iron might be taken as the limit of solubility, and this was the safe working limit for articles which had to be spun, cupped or drawn. Iron will neither affect the tenacity nor the hardness of beta-brasses, and its common use in high tenacity brasses was due to the manner in which it affected the crystal growth. Mr. Smalley's paper, which lack of space forbids us to abstract as fully as it deserves, gave the full tests of series of alloys of the kinds already mentioned, and many others, such as the aluminium-manganese brasses and aluminium-manganese-iron brasses. It also included much practical information concerning the manufacture and casting of these alloys. In the short discussion which followed, manganese-brasses were said to have got a bad name among engineers because many of them were of extreme complexity and test results could not be repeated with certainty. One firm in this country was said to be importing brass from France, because the English brasses were too free from lead, and this constituent enabled the metal to be machined better. All high-tenacity brasses were said to be founded on a 60 : 40 mixture with very small additions of other elements. In his reply the author stated that up to 0·75 per cent. lead had no appreciable effect on the strength of a brass. The meeting awarded the author the usual vote of thanks, and proceeded to the consideration of the eighth and last paper of the conference.

LIGHT STEEL CASTINGS.

This paper, the full title of which was "The Manufacture of Light Steel Castings," was read by Mr. H. Bradley. It was a short paper of a general nature, describing the author's experience and views of the management of a general jobbing steel foundry making all classes of castings from a few ounces in weight up to 14 tons, and with metal containing from 0·08 per cent. to 1 per cent. of carbon. Referring to moulding, the author said that a good wood pattern could be used for 500 moulds, either by hand or machine. For repetition work brass or white-metal patterns were necessary. For boxes up to 24 in. round or square the author preferred the hydraulic moulding machine, and for deep-lift patterns the roll-over machine. For anything over 24 in., the jar-ramming machine was the best. Moulding machines speeded up the work. Two boys working a machine with boxes 10 in. by 10 in. by 4½ in. could produce 180 complete moulds in a day, with from two to four cores in each. Two youths about 18 years of age, had produced 62 moulds, 18½ in. by 16 in. by 5 in deep, painted and blacked.

Bottom runners were the best whenever possible, and they should take the metal to the thinner sections of the casting. Soon after casting all runners and feeding heads should be removed to enable free contraction to take place. To secure good, sound steel castings the designer should always aim to have as nearly as possible equal thickness of metal in the casting. Where there was a great and unavoidable change in the thickness of metal, the difficulties could be mitigated by using chills or causing the thick portion to freeze at about the same time as the thinner parts. In some cases a reinforcement was used, but this was not always advisable, as if the casting broke and disclosed the reinforcement, the method was blamed. The discussion brought out the opinion that sufficient importance was not given to the question of sand concerning which our knowledge was much less than that of steel. Electric welding was a necessity in any steel foundry and was preferable to acetylene welding. If designers would work in collaboration with founders, much better and cheaper castings would be obtained. One speaker said the proper casting temperature was the hottest that could be obtained, metal could not be got free from cracks if poured too cold. Another maintained that dry-sand moulding was cheaper than green-sand moulding, and that it would not scour, but the general opinion seemed to be that green sand was preferable, one speaker saying that he had cast a very large number of lorry wheels in green sand and had never had one returned, and that up to 14 cwt. he would not advocate dry sand for anything.

The very successful conference concluded with a vote of thanks to the civic authorities for the use of the hall in which the meetings had been held.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 821 *of vol. cxiii.*)

Gear Testing Machines. (Dr. Stanton, Mr. Hyde.)—The full-scale worm-gear testing machine of the Lanchester type and the machinery and tilting frames for testing the efficiency of spur and chain gears, were illustrated last year (see page 11 of ENGINEERING of July 1, 1921). The latter machine was then a model for 1 h.p.; a large machine, for 50 h.p., has now been built, and the two testing machines have been erected next to one another with the prime motor between the two. They are thus convenient for complete sets of tests.

A series of tests made on a worm gear designed for use on the rear axle of a 12-h.p. Rover motor car gave a maximum efficiency of 93 per cent., with castor oil as lubricant, at the higher torques between speeds of 500 r.p.m. and 2,500 r.p.m., and at loads corresponding to the transmission of powers ranging from 0·5 h.p. to 80 h.p. Four different oils were also tested at different temperatures up to 80 deg. C., the worm shaft running at 1,000 r.p.m. The efficiencies of the four oils ranged from 92 per cent. to 90 per cent., falling off by 1 per cent. mostly as the temperature rose above 50 deg.

A new interesting machine for gear testing has been presented by the Power Plant Company of West Drayton, who had so far not made any practical use of the arrangement. There are two parallel lines of shafting running in ball bearings. The long shaft carries two equal double helical wheels, one coupled with the gear under test, the other running independently on a sleeve, and further out are two discs, the one on the shaft, the other on the sleeve. The two discs are joined by a flexible coupling. The second shaft carries two small helical wheels, both keyed to their common shaft and engaging with the large wheels above mentioned. This second shaft is driven by an electric motor, and the power absorbed by the motor is a measure of the power loss in the gearing.

Roller Bearings for Tram Cars. (Mr. Hyde.)—On behalf of the Hoffmann Company, of Chelmsford, Mr. Hyde has been conducting comparative tests on two double-deck tramcars at Wigan, the one fitted with Hoffmann roller bearings, the other with ordinary bearings; and similar tests are now being made for the London County Council. The tests concerned electric power consumption, tractive resistance, starting effort and retardation, the apparatus including the draw-bar dynamometer of Mr. Hyde. On service runs the power reduction in favour of the unloaded Hoffmann car was 30·5 per cent., 22·2 per cent. on the loaded car, and 22·1 per cent. with frequent stops. The tractive resistance tests gave advantages of 20·5 per cent. to 22·7 per cent. (loaded cars) and 24 per cent. to 27 per cent. (unloaded); the starting effort of the Hoffmann car was one-twentieth that of the ordinary car, and the retardation tests showed that with speed up to 20 m.p.h. the Hoffmann would run 57 per cent. further than the other after shutting off the current.

Tests of Heavy Oils. (Mr. C. Jakeman.)—In order to compare the performances of lubricants at high temperatures (up to 250 deg. C.), pressures (loads of 1,000 lb. per square inch) and velocities (1,300 r.p.m.), Mr. Jakeman makes use of a modification of his apparatus for journal-friction tests which we described and illustrated on pages 866 and 867 of our issue of June 25, 1920. The 2 in. journal is at the end of a larger shaft and is hollow; a gas flame is introduced into the hole, the hot gases passing into a cage surrounding the bearing, which has a length of 2 in. A thermo-couple is placed in a hole in the top of the bearing, the hole passing not quite through the bearing. A displacement ram, driven by an independent electric motor, forces the adjustable amount of oil into the bottom of the bearing, at a relatively small pressure. In order to avoid the formation of air pockets no pressure gauge was fitted; the accidental appearance of an air bubble was found to cause immediate seizure. Plotting the change of friction μ against temperature, regular U curves were obtained, showing a minimum between 90 deg. and 120 deg. C. (depending upon the oil); after this minimum had been passed the friction increased again then until seizure occurred. Heavy mineral oils attained the highest temperatures without seizing, and the temperature of seizing was lowered by the addition of fatty acids to mineral oil. In order to avoid damage to the seized shaft, a fairly stiff driving belt was used on flat pulleys; the belt slipped at once when the friction increased suddenly. The seizure produced scoring marks, except with neatsfoot oil, which gave a burnished surface and removed the previous scoring marks of other oils. There are some peculiarities further to be studied in the curve between about 120 deg. and 140 deg. C.

Fatigue of Motor Lorry Beam Springs. (Mr. G. A. Hankins.)—On the suggestion of the Chief Inspector of Mechanical Transport of the War Office, the effect of heat treatment and of the composition of laminated lorry springs, are being investigated with the aid of a special fatigue-testing machine adapted to the shape of these springs. The specimen, 3 in. by $\frac{3}{8}$ in. in section, is clamped horizontally to a rigid base at one end and carries a bracket at the other end; the bracket is provided with bearings in which a high-speed spindle carrying two unbalanced discs can rotate; this is driven by an electric motor. By regulating the speed and the unbalanced mass a periodic vibration of the cantilever specimen can be maintained of sufficient amplitude to produce fracture at the clamping point. In one case the amplitude was, at 2,362 r.p.m., 0·44 in., and fracture occurred after 5,000,000 vibrations.

Determination of Fatigue Range of Stress on a Single Specimen. (Mr. H. Gough.)—Mr. Gough's new method of fatigue testing, which excited so much interest last year, has been further developed with important results. For the ordinary tests of

AUTO-HORSE TRACTOR AT THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

CONSTRUCTED BY MESSRS. W. TASKER AND SONS, LIMITED, ANDOVER.

(*For Description, see opposite page.*)

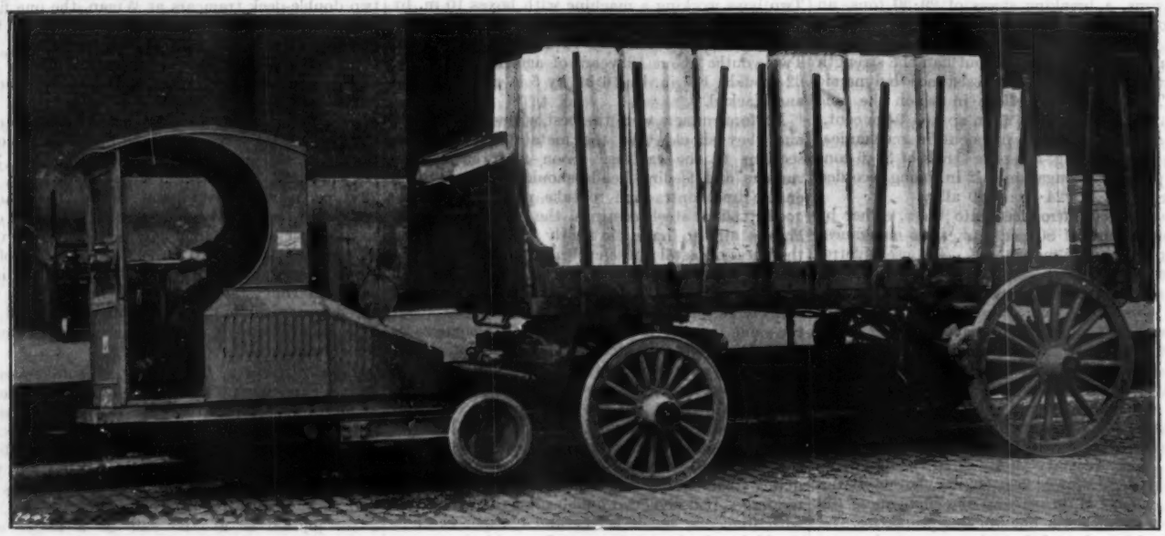


FIG. 1.

fatigue ranges, about six specimens are required. Mr. Gough combines the single-specimen methods of J. H. Smith (an optical extensometer is attached to the specimen under tensile stress) and of Stromeyer (the specimen is subjected to alternating torsion and the temperature of the water circulating through the jacket is determined), using a thermo-couple for the calorimetric measurement instead of the water jacket. The tests so made are in agreement with the results of ordinary Wöhler tests. Further, the method of yield ranges has, with the aid of a mirror extensometer, been extended to specimens submitted to reversals of bending stress on Wöhler machines. By these methods the limiting range of stress can be determined within half an hour. Very interesting results have been obtained with copper. Copper has no primitive elastic limit, large plastic strains occurring with the application of very small loads; but after the application of 2,200 reversals (bending stress) the copper became distinctly elastic. We hope to give further particulars of these researches.

Detonation in Internal-Combustion Engines. (Mr. R. W. Fenning.)—The apparatus used was described in our issue of June 25, 1920, page 867. A gas or vapour explosion is produced in a steel cylinder, 7 in. diameter, 8 in. high, and deflects a steel diaphragm flush with the inside of the upper cover through 0·003 in. maximum; this movement is optically magnified up to 1,500 times and photographically recorded. The experiments were made first with mixtures of hydrogen and air, quiet or stirred, and then with fuel vapours, produced by passing air through the fuel and heating the vapours electrically; the curves are regular, rising sharply to a maximum and then falling off slowly, provided no detonation wave be set up. In mixtures of 1 volume of hydrogen to 2 or 3 volumes of air at 50 deg. C. and 16·6 lb. per square inch (initial) the time interval between spark and pressure maximum increased with the strength of the mixture, the shortest intervals being 0·007 second after the passage of the spark and 0·005 second after commencement of the pressure rise. When the initial temperatures were 100 deg., 200 deg., 300 deg. C., and the pressures (reduced to 15 deg. C.), 1, 2·5, 4·7 atmospheres, these intervals were reduced to 0·005 second and 0·004 second, in complete-combustion mixtures; at 300 deg. C., however, the results were already vitiated by the slow combustion of the gases. Turbulence (produced by churning the mixture with a fan) further reduced the intervals in weak mixtures, but had little effect in strong mixtures. Firing by a series of three sparks (instead of one spark) also shortened the intervals and slightly increased the maximum pressure; the shortening of the explosion cylinder (from 8 in. to 2 in.) had similar effects.

Heat Loss from Steam Pipes at High Temperatures. (Mr. C. Jakeman.).—For the determination of the heat losses from pipes for superheated steam at high temperatures, up to 1,000 deg. F., Mr. Jakeman is making use of a novel arrangement, while adhering to the dimensions of his previous apparatus for pipe covers, so that the results of the new tests will be comparable with the old ones. The idea is that two sections of a 4-in. pipe, equal in all respects except that the one is 13¾ ft., the other 2 ft. in length, are arranged in alignment; the ends facing one another are exactly similar, and so are the internal heater coils. The temperature of the pipe itself is determined by treating it as resistance while a low-potential current is passing. The various observations give the heat losses from a pipe of a length of $(13\frac{3}{4} - 2) = 11\frac{3}{4}$ ft. The research was undertaken on the instigation of one firm, but several firms are interested in it. We reserve further details. One covering material gave an efficiency of 92 per cent.

Fire Prevention on Aircraft. (Mr. Hankins.)—Since particles of wood, grass, &c., might be ignited by coming into contact with the hot exhaust pipe of a crashing machine, Mr. Hankins has made experiments with hot plates. Dry wood chips were ignited when the plate was at 430 deg. C., paper and dry grass at 450 deg., rubber insulation stood 600 deg. C. without catching fire, and glowing wood failed, in 300 experiments, to ignite explosive petrol vapour. In similar experiments with liquids kept near the hot plate (or thrown on it) ignition occurred: with paraffin at 300 deg. C., petrol at 460 deg., mineral lubricant at 330 deg., benzol not even at 590 deg. C.

Heat Emission from Thin Plates exposed to Air Currents.—Miss D. Marshall is continuing this research (see page 10 of our issue of July 1, 1921), which is important for ascertaining the distribution of the intensity of skin friction and the manner in which turbulence sets in, when a stream of fluid impinges on the edge of a flat plate parallel to the stream direction. Heat emission seems to depend more upon the general turbulence of the fluid near the surface than upon the actual value of the skin friction. The Pitot tube we illustrated last year (page 10, vol. cxii), and an air channel of 5 in. diameter are used.

Air Currents in the House of Commons. (Mr. A. Bailey.)—On being consulted by the Commissioner of Works as to the improvement of the ventilation in the House of Commons, Dr. Stanton had suggested the preparation of a ¼ scale model of the Debating Chamber for systematic experiments. With this model Mr. Bailey has been experimenting by trying various alterations, for instance, by reducing the vertical currents through the floor grids and increasing the air delivery through the ducts in the side walls under the galleries. In these experiments he makes use of a directional hot-wire anemometer, for determining the speed and direction of air currents at any point in a plane. The anemometer consists of a 4 mil platinum wire, 1¼ in. long, parallel to which a manganin wire, 0·6 mm. (0·024 in.) in diameter is mounted at a distance of 3 mm. to serve as a screen; the two wires are joined in series in one arm of a Wheatstone bridge, being carried by an ebonite plug fixed to a piece of brass tube (enclosing the leads) which can be rotated; the inclination of the plane of the wires is noted. The screening effect vanishes when the inclination of the wire plane to the wind direction exceeds 20 deg.

Road Laboratory. (Mr. Batson.)—The road machine having been off duty since 1916 has been overhauled, and this involved altering the mode of lubrication. An 1½ in. bituminous carpet has also been laid in two thicknesses and tested in the dry and wet, with loads increasing from 3 cwt. up to 20 cwt. on the wheels, 3 in. wide. The total surface mud, dried and weighed, amounted to a wear of 0·05 in. at the completion of the test. The mixing plant for the production of the asphalts, out of which the carpets to be tested are formed, was planned in 1915, but has only now been supplied by the Ransome Machinery Company, and has been installed in a hut. It is a full capacity standard plant, especially fitted for controlling the weights and temperatures of the ingredients and for the rapid transport of the mixture to its position in the model track. The weighted road materials pass through a rotating drum, in which they are dried by the hot gases from a furnaces underneath the drum, and

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

MESSRS. BARFORD AND PERKINS, LIMITED, ENGINEERS, PETERBOROUGH.

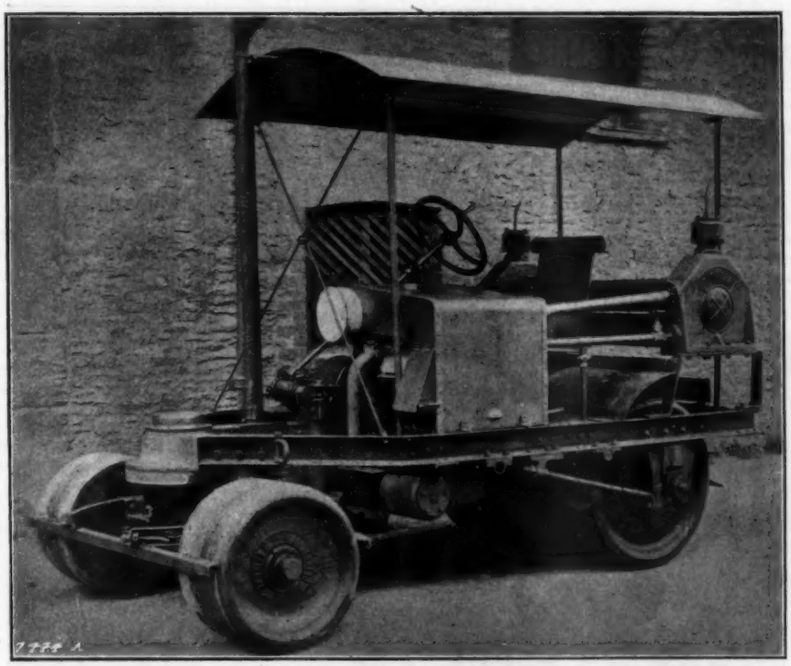


FIG. 2. THREE-WHEEL MOTOR ROAD ROLLER.

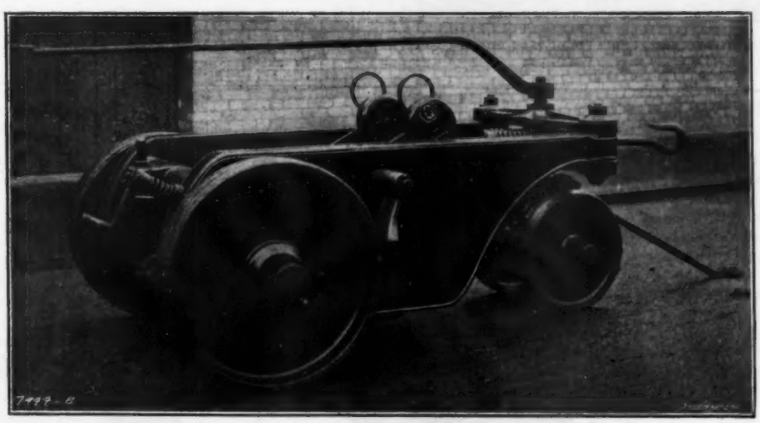


FIG. 3. ROAD SCARIFIER FOR USE WITH MOTOR ROLLER.

are delivered at the desired temperature into an elevator and into two hoppers, to be mixed with weighed bulks of bitumen. The tests of one road take a month.

Testing Reinforced Concrete. (Mr. Hyde.)—The big machine, made by Messrs. Redpath, Brown and Co., and mentioned last year, has proved a most useful addition to the plant. The steel frame was designed by Mr. J. R. Sharman, of that firm; the design of the loading and load-measuring arrangements and of the ingenious apparatus for determining compression of columns and deflection of floors is due to Mr. Hyde. The machine accommodates floors up to 14 ft. span, 6 ft. wide and 15 in. thick, and columns 8 ft., 12 ft., 16 ft. or 20 ft. long. The deflection of a floor is measured by a water level consisting of two cups connected by a tube; the one cup has a surfaced bottom and rests on a small location plate cemented to the floor, the other cup is fixed to a rigid part of the machine. Each cup carries a micrometer, and readings are taken with the floor cup in selected positions on the floor surface. The method gives the deflection of the floor between the supports, independent of any local crushing at the point of loading or under the supporting beam, and independent also of any bodily movement due to strain in the machine. The deflection can be determined accurately to 0·0005 in. Preliminary tests with floors of various thicknesses with the same reinforcement in each tend to show that, when the strength of the reinforcement is 1, a flush concrete filling will not increase the strength, but as the thickness rises the strength may increase to 5.

For the tests of columns special knife-edge pivots have been designed. The pivot consists of two brackets; the lower bracket carries a cross-piece on steel knife-edges arranged along its length, the arms of this cross-piece, at right angles to the knife-edges, supporting the upper bracket (which is inverted) through a second set of edges. The whole thus forms a pivot with two sets of knife-edges working on plates arranged in the same plane, the two sets being at right angles to one another. Pivots are provided for maximum loads of 15 tons and 50 tons. The shortening of the column under test is measured by the aid of four rods suspended from a plate fixed in the plane of the top end pivot; the rods engage micrometers fixed in a similar plate level with the lower pivot. The sum of the four readings gives the total shortening of the column, and the individual readings allow of determining the mean axis of bending. Effects of temperature are provided for, and measurements can be made with ease to 0·0005 in. The knife-edges in question are square bars, about ¾ in. side, resting in V grooves; when the upper edge is slightly blunted, another edge can at once be brought into position.

(To be continued.)

THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

THE Show of the Royal Agricultural Society, which opened at Cambridge last Tuesday is the eighty-first of the long series of exhibitions organised by the Society, and the third to be held in Cambridge. The meetings have been held annually—with the exception of the year 1866, when the show was abandoned in consequence of the cattle plague. The first show at Cambridge was in 1840, two years after the foundation of the society, and with its 115 implements and 247 live-stock, only occupied 5 acres of ground. When it returned in 1894, there were 6,031 implements and 1,864 head of stock entered, and the show grounds extended to 64 acres. This year there are 4,866 articles entered under the very comprehensive heading of implements, which includes, besides machinery, manures, feeding stuffs, &c., while the live-stock entries number 4,200, which is a record for the society. No less than 120 acres of land have been enclosed upon this occasion. Compared with the Derby Show last year, the implement section is slightly smaller, the stands numbering 494, as against 508 and the shedding 12,191 sq. ft. as compared with 13,990 sq. ft. at Derby, these figures being exclusive of open spaces. A substantial profit accrued from the Derby Show, and as the last Cambridge Show resulted in a profit, it may be hoped that good fortune will attend the present venture, for the society is deserving of all support in its work on behalf of British agriculture.

The general impression given by the show is that it is not greatly different from others of recent years. A few well-known exhibitors are absent on this occasion, and the displays of others have been affected by the recent engineering stoppage, but every kind of modern agricultural machinery is amply represented. Agricultural tractors do not seem so much in evidence as at Derby and Darlington, but nevertheless we counted 17 different makes, and possibly there were more. Two only were of the caterpillar type, which seems not to make headway, and will possibly disappear so far as ordinary farm purposes are concerned. The portable steam engine, formerly the standard prime mover of the farmer, is on the verge of extinction, only two examples of it being noticed at the show. The traction engine and the steam tractor still hold their own, but they are probably now of much more interest to contractors and hauliers than to agriculturalists.

Messrs. W. Tasker and Sons, Limited, Andover, Hants., show two interesting vehicles, one a six-wheeled steam lorry of 10 tons carrying capacity, and the other an "auto-horse." This latter is of American origin, but is built in this country by Messrs. Tasker on behalf of Messrs. S. E. Leach, Limited, of 16, Brown's Buildings, Exchange-street West, Liverpool, who are the sole British and Colonial licensees. The auto-horse, which we illustrate on the opposite page, is somewhat difficult to describe. It is a single-wheeled tractor when working, but two small road wheels support its rear end when moving from one job to another. It consists of two horizontal steel frames, the lower one, which is attached to the lorry or trailer to be drawn, is very simple, its most important feature being a large circular rack with internal teeth. The upper frame rests on the lower one. On one side of it is a vertical four-cylinder engine, 95-mm.

bore by 140 mm. stroke, mounted in a fore-and-aft direction and balanced by a weight on the opposite side. The engine drives a horizontal transverse shaft through a change-speed box and bevel gear, and this shaft drives the single driving wheel by a sprocket chain. The steering wheel operates a pinion gearing into the circular rack of the under-frame, so that if the steering wheel is turned, the whole upper part of the machine including the engine and the driving wheel rotates about the driving wheel as a pivot.

The front axles of all vehicles to be pulled are fitted with catches in front. Behind the fixed frame of the auto-horse is a sort of horizontal linch-pin, which when the auto-horse is backed against the vehicle, slides up the lower inclined jaws of the catches and is held against return by passing under a detent. This raises the small road wheels of the tractor clear of the ground, and the combination is then ready to go on. The nature of the auto-horse makes it able to manœuvre either itself alone, or any vehicle attached to it, in the most confined situations. The machine by itself will turn about a centre midway between its little road wheels, if the top frame is rotated through 90 deg., and will run round and round in a space very little larger than itself. The idea underlying the design was to provide a tractor which could be instantaneously attached to, and detached from, any standard vehicle, so that it could be always at work, as during the time when any particular vehicle was being loaded or unloaded it would be hauling another one. It is efficiently sprung, and has seating capacity for two persons. Its overall length is 11 ft. 9 in., its width 5 ft. 3 in., and its weight about 2½ tons.

The internal-combustion engine now quite dominates the show so far as power is concerned. From tiny little things of about 2 b.h.p. to engines of over 100 b.h.p. running on suction gas, all types and sizes are in evidence, applied to every purpose which could interest a farmer large or small. In the larger engines there has never been any foreign competition, but until comparatively recently the smallest and cheapest engines were almost entirely imported from America. It is gratifying to see that British makers are rapidly regaining this field, the home product being usually no dearer and always noticeably better in quality.

Messrs. Barford and Perkins, Limited, of Peterborough, show seven motor rollers weighing from less than 2 tons to over 10 tons. One of their standard machines of medium size is illustrated in Fig. 2, on page 9. The largest machine on their stand is a three-wheel, water-ballast roller, weighing 10 tons empty, and 2½ tons more when water ballasted. It is notable as being fitted with a scarifier, which, though a common attachment to steam rollers, had not heretofore been used in connection with motor rollers. The roller has three forward and two reverse speeds. Scarifying is done in one direction only, at the lowest speed of 1·25 m.p.h., the machine returning at the top speed of 4 m.p.h. The engine is of 30 b.h.p. to 40 b.h.p., and will run either on petrol or paraffin. The back rollers are 1 ft. 8 in. wide by 5 ft. 6 in. diameter, and the front roller is 4 ft. wide by 4 ft. diameter. The independent road scarifier illustrated in Fig. 3, page 9, is also exhibited by Messrs. Barford and Perkins, Limited. It is extremely simple, consisting of two heavy side frames, between which are the double-ended scarifier tines. These can be thrown over, for working in either direction by altering the position of a weighted lever.

The National Gas Engine Company, Limited, of Ashton-under-Lyne, Lancashire, show many sizes and types of gas and oil engines, from 3½ b.h.p. to 185 b.h.p., but one of the most interesting of their exhibits is the portable wood refuse, suction gas plant and engine which we illustrate in Fig. 4, page annexed. This is an entirely new production of the firm. The engine, which develops 5 b.h.p. at 400 revolutions, is of the ordinary horizontal open type. It works with the gas made by the producer mounted at the rear of the bogie. The producer is a tapered cast-iron shell, having a brick lining at the lower end. Gas is made from wood refuse which is put through the top. Here it becomes dried and carbonised by the heat and

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

MESSRS. THE NATIONAL GAS ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE.

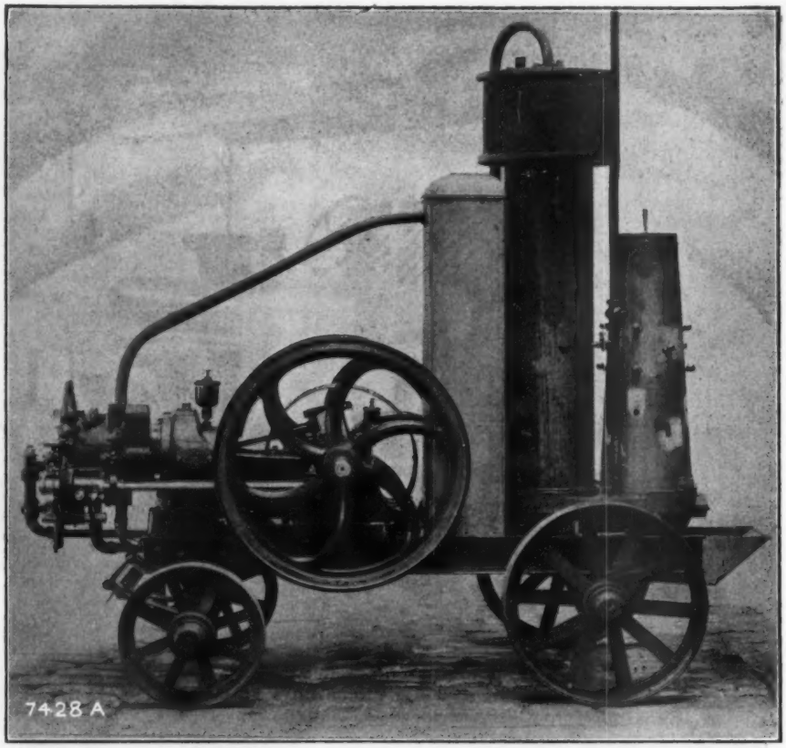


FIG. 4. PORTABLE SUCTION GAS PRODUCER AND 5 B.H.P. ENGINE.

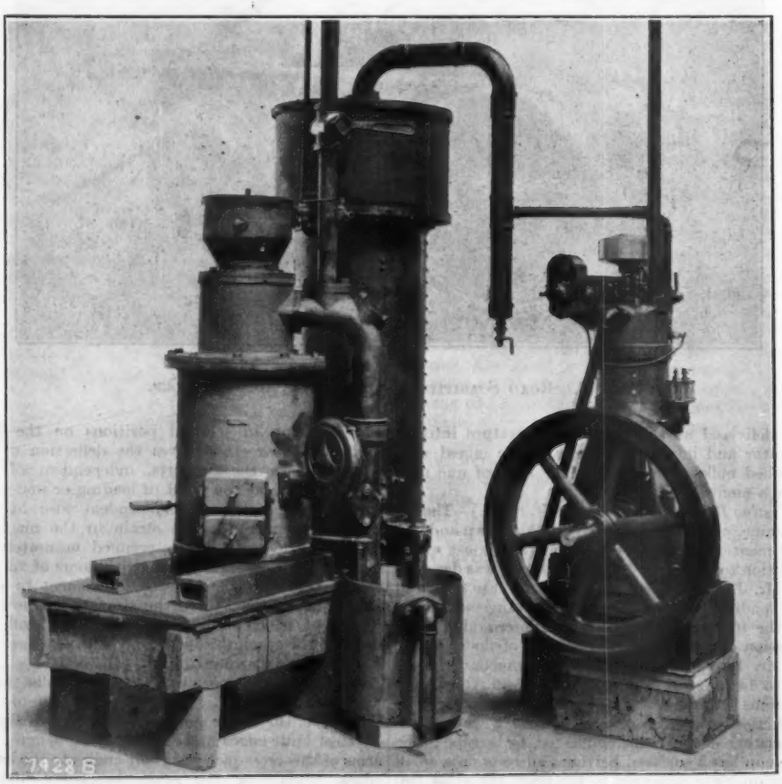


FIG. 5. FIXED SUCTION GAS PRODUCER AND 5 B.H.P. ENGINE.

gradually descends into the fire zone. The producer works on the down-draught principle, which does away with the tar difficulty. Air is led into the producer through a vertical pipe which terminates in the combustion zone, and it also enters the same part through small holes in the side of the producer shell. No water or steam is supplied, as all wood contains enough moisture to make good gas and to keep the temperature of the fire down. Ashes are discharged as required by operating an external lever which shakes the grate bars and dumps the ashes into the water seal beneath. The gas leaves the bottom of the producer and then travels upwards through a coke-scrubber and a dry scrubber in series, and so to the engine. No tar extractor is needed. Any kind of wood refuse chopped or sawn into pieces which will go into the producer, suffices for fuel, and the consumption of fuel varies from 2·5 lb. to 4 lb. of wood per brake horse-power hour, according to the nature of the wood. The engine is also fitted to run on petrol, so that it can be operated on that fuel if power is only needed for so short a time that it is not worth while lighting up the producer. In places where wood refuse is available, and particularly abroad, the plant should prove a very simple and economical source of power. It is capable of threshing and cleaning from 760 bushels to 830 bushels of wheat in a 10-hour day. With barley the output is 25 per cent. greater and with oats 50 per cent. greater than with wheat.

The other exhibit of the National Gas Engine Company which we illustrate is a small fixed suction gas plant, designed for anthracite charcoal fuel. It is shown on the stand driving a 5 b.h.p. vertical engine coupled to a 3-kw. generator. The engine, which develops its rated power at 600 revolutions, is adaptable for petrol, paraffin, town gas or suction gas, the change-over being effected in less than an hour, so that if any kind of fuel fails the plant can soon be in operation again on an alternative kind. On the same stand are shown two small engines made by Messrs. Mirrlees, Bickerton and Day, Limited, of Stockport, near Manchester, which are very interesting mechanically. The engines are of the vertical air-cooled four-cycle type, but both inlet and exhaust are controlled by a single mushroom valve. In the cylinder head, adjacent to this valve, is a rotary valve driven by the same camshaft as works the mushroom valve. This rotary valve only fits loosely in its chamber and acts as a deflector, putting the mushroom valve alternately in communication with the inlet gas and the exhaust. The passage of the exhaust gases heats the rotary valve, and this heat is given up to the incoming paraffin mixture which flows over the valve, thus providing good conditions for vaporisation. The camshaft is driven by a sprocket chain. The single mushroom valve permits of a symmetrical and well-proportioned combustion space. The cooling fins on the cylinder are vertical and are surrounded by a thin sleeve, air being drawn down over the cylinder head and along the cylinder walls by the fan action of the flywheel. The two engines referred to each develop 3·5 b.h.p. at 1,000 r.p.m., and run on paraffin. One is shown direct-coupled to a dynamo and the other to a small air compressor.

Messrs. J. and F. Howard, Limited, of Bedford, are exhibiting a great deal of agricultural machinery, such as ploughs, cultivators, hoes, straw trussers, &c. The firm are showing for the first time the patent spading harrow, which we illustrate in Fig. 6, annexed. This works somewhat on the principle of the disc harrow, and behaves as one might expect a disc-harrow to do if the discs were replaced by radial blades. The blades in the present case are of forged steel and slightly twisted. The standard width of the machine is 6 ft., and it is said to dig from 4 in. to 6 in. deep in suitable soil. Heavy and lumpy clay soil is cut and moved sideways by the action of the machine, so that it becomes broken up and aerated.

Messrs. Marshall, Sons and Co., Limited, of Gainsborough, show a very comprehensive collection of their manufactures. Some of their exhibits are illustrated on page 16. The mechanical flax puller shown in Fig. 7 has been developed in conjunction with the Fibre Corporation, Limited. Flax, as is generally known, has to be pulled up, if wanted for fibre, as cutting it is obviously not permissible. The labour of pulling flax is very great and on this account the cultivation of the plant had died out in England before the war. The stoppage of the Russian supply of flax caused its cultivation to be re-introduced, and much money has been spent in endeavours to perfect a machine to pull it. It is essential that the stalks shall not be bruised, nor must the seed bolls be pulled off, and, of course, no flax ought to be left unpulled. Any machine also must be uninjured by thistles, docks and other weeds which will not come out of the ground easily. The Marshall machine consists of a rectangular steel frame carried on two wheels, one of which acts as a driver. The driving wheel actuates a horizontal shaft at the back of the machine by means of a sprocket chain. This shaft can be clutched into another one which drives a pair of endless chains carrying a series of steel combs at the ends of arms. As the machine goes forward, these combs move backward relatively to the frame and pull out the growing flax which gets gently wedged between their

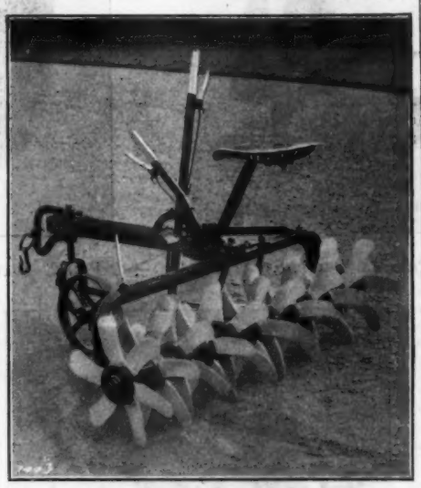


FIG. 6. SPADING HARROW; MESSRS. J. AND F. HOWARD, LIMITED, BEDFORD.

fingers. A stripper connected to each comb, slides along the teeth and removes the flax which is deposited on the ground at regular intervals as the machine moves forward. The machine takes a 36-in. swath and will pass through a 9-ft. gateway. It is unusually well built for an agricultural machine, and weighs 18 cwt. It is said to perform highly satisfactory work, pulling from 5 acres to 10 acres a day, according to the nature of the crop.

The compound steam tractor of Messrs. Marshall, shown in Fig. 8, is noticeable on account of the use of radial valve gear for both cylinders, and also because of its self-staying fire-box. Each slide valve is operated by a single eccentric, and cut-off is varied, and reversing effected by the angular motion of a slide. The absence of slotted links and the great reduction on the number of parts are advantageous, particularly in machines subject to severe operating conditions. The boiler pressure is 200 lb. per square inch, and the complete absence of fire-box roof-stays, which is made possible by the dishing of the crown plate, enables the interior of the boiler to be more effectively cleaned. The cylinders of the engine are 4·75 in. and 8 in. diameter by 8-in. stroke. All gears except the last are machine cut, and the gear runs in an oil bath. There is a rim brake acting on both hind wheels, and the engine is fitted with a winding drum for hauling itself or its load out of a bad place. Messrs. Marshall, Sons and Co., Limited, also show three oil engines, two portable and one fixed; the latter is illustrated in Fig. 10. This is rated at 8 b.h.p., and, like the others, works on the two-stroke cycle, and therefore has no valves. The engines use heavy oil up to a specific gravity of 0·92 as fuel and require no lamp except at starting. No water injection is used in the cylinders. Fig. 9 shows an all-steel threshing machine recently designed by the same firm. The frame is of angle and channel steel, sheeted in with thin planished steel, and great rigidity and strength are claimed for the design. The machine is of the finishing type, which threshes the grain, cleans it, grades it and leaves it fully prepared for market at one operation. It weighs about 3·5 tons, which is considerably lighter than wooden machines of corresponding size. All important bearings are of the self-aligning ball type, which makes the machine very light to drive.

(To be continued.)

A TRANSFORMER LOAD INDICATOR.

A SIMPLE instrument, or device, for determining the load on distribution transformers has been introduced by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Pa., U.S.A. The instrument takes the form of an indicator which may be mounted in the drain plug hole of an oil-immersed transformer, or in a special hole in the side tank wall a few inches below oil level. The indicator operates in terms of the oil temperature which is, of course, a function of the load on the transformer. When a predetermined temperature has been reached a semaphore on the indicator drops into view. The semaphor has an area of about 2½ sq. in., and is coloured a distinctive yellow so that it may easily be seen. The device is of service not only for indicating when an individual transformer is overloaded, but also for indicating whether transformers operating in a bank, or in parallel, are properly dividing the load.

The arrangement operates by means of a bi-metallic strip, one end of which is set in a tube which projects through the hole in the transformer case into the oil, and the outer end of which latches the semaphore in position. With increase of temperature the bi-metallic strip bends and releases the semaphore which falls by gravity. The semaphore is reset by simply pushing it back into place. The apparatus may be set to operate at any temperature within the range of adjustment by setting a trigger on a numbered scale. The indicator responds to the temperature of the oil in which the tube carrying the inner end of the bi-metallic strip is placed. As the object is, however, to obtain an indication when the hottest part of the winding has reached a temperature of 105 deg. C., it is necessary when setting the indicator to allow for the difference in temperature between the hottest part of the winding and the temperature of the oil at the top or bottom of the tank where the instrument is placed. For average operating conditions it is generally found satisfactory to set the indicator to trip when the oil at the top of the tank reaches a temperature of 80 deg. C., or when that at the bottom reaches a temperature of 70 deg. C. Special operating conditions may, of course, call for a departure from this rule. The trigger setting allows of a tripping range varying between 50 deg. and 100 deg. C.

DIESEL ENGINE ELECTRIC PROPELLING MACHINERY.—Messrs. Cammell Laird and Co., Limited, of Birkenhead, have received an important order from the United Fruit Company, of Boston, U.S.A., for three insulated motor ships for their fruit business. The vessels are of about 4,000 tons gross and will be propelled by electric motors, the current being generated by "Camellaird-Fullagar" Diesel engines. This combination of machinery marks a new era in this country in ship propulsion, and is certain to have a big influence on the future of marine engineering. It is claimed that by the adoption of this combination of machinery there is an enormous reduction in fuel consumption, and greatly increased cubic space and deadweight capacity, and the machinery lends itself to the greatest flexibility of control.

BRITISH ELECTRIC LOCOMOTIVES FOR JAPAN.—The Imperial Government Railways of Japan have just placed with the English Electric Company for their Dick Kerr Works at Preston an order for 34 complete electric locomotives of the total value of upwards of 500,000*l*. This represents the whole requirement of locomotives up to the end of 1923 for those sections of their main line railways which the Japanese Government have decided to electrify at once. Eight of the locomotives are for heavy express passenger service. They are of the 2–C–C–2 type. Their weight is approximately 96 tons, and they are designed to haul a 415-ton train at a balancing speed of about 60 m.p.h. Each locomotive is equipped with six motors rated at 306 h.p. at 500 volts, the motors being connected in two groups of three in permanent series on a trolley voltage of 1,500 volts. The control equipment is of the standard "English Electric" camshaft multiple-unit type. Of the remaining locomotives, 9 are for local passenger service and 17 for heavy freight service. These 26 are all of the B–B type, and will weigh approximately 56 tons each. They are equipped with four motors similar to those on the express passenger locomotives, but in this case the motors will be connected in two pairs in permanent series. Here, too, the control is the standard "English Electric" multiple-unit type. The locomotives for local passenger service are designed to haul a 315-ton train and the freight locomotive a 600-ton train, the balancing speeds being about 35 m.p.h. and 40 m.p.h respectively.

4-IN. SCREW-CUTTING BACK-GEARED FOOT OR POWER LATHE.

CONSTRUCTED BY THE BRITANNIA LATHE AND OIL ENGINE COMPANY, LIMITED, ENGINEERS, COLCHESTER.

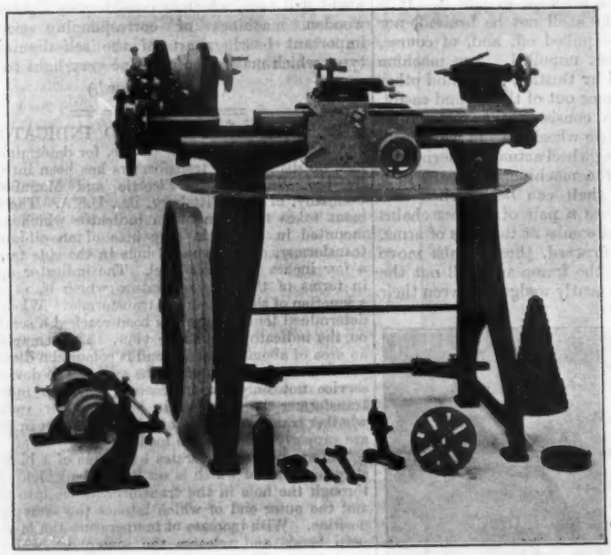


FIG. 1. LATHE ARRANGED FOR TREADLE DRIVE.

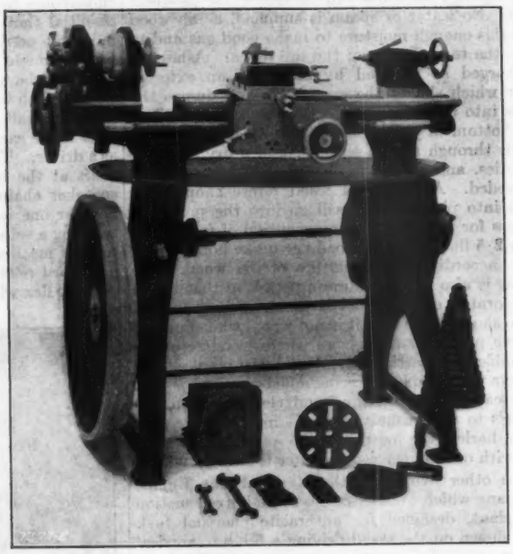


FIG. 2. LATHE WITH SELF-CONTAINED ELECTRIC DRIVE.

THE name of the Britannia Lathe and Oil Engine Company, Limited, of Britannia Works, Colchester, has long been well known in connection with small lathes, and a description of the new 4-in. model which the company is now producing, and which is illustrated on this page and opposite, will be of general interest. This model has been introduced since the war and has been manufactured in very large quantities. Up to the present, however, the whole of the output has been disposed of under a trade arrangement, and, although the term of this arrangement has not yet expired, the Britannia Company is now free to sell the lathe directly in the open market. The centres of the lathe are 4½ in. high, and a piece of work 25½ in. long can be accommodated between them. The bed is formed with a gap 4½ in. long, in which a job 11½ in. diameter can be swung. The lathe is back-geared, and is fitted for screw-cutting and self-acting sliding and boring. Among its special features are the milling, grinding and sawing attachments which have been designed in connection with it. These special attachments, to which we will refer in detail later, are remarkable for their simplicity. The variety of work which can be carried out on the lathe would, with most other makes, be found to require fairly expensive and complicated overhead gear.

The lathe is arranged for driving by foot treadle, as will be clear from the general view given in Fig. 1, but it may, of course, be driven overhead from a countershaft and may be mounted as a bench lathe. An ingenious and neat self-contained electric drive has also been worked out, and is illustrated in Fig. 2. As will be clear from that figure the electric motor is incorporated in one of the legs and drives on to the flywheel by means of a cross-shaft, friction gear and gear wheels. The bed is of box-section and, as will be clear from the figures, is supported at two points. Its upper surface is formed with two 90-deg. inverted vees, on which the saddle travels. In this feature the lathe follows American and Continental practice. The saddle is entirely located by the vees and does not bear on the strip in front of the bed. With a flat bed, as is well known, the accuracy of the lathe depends on the parallelism of the wide part of the bed, and when this is worn it is impossible to adjust the lathe accurately. In lathes on general work this wear usually takes place at the left end of the bed. With the 90-deg. inverted vees wear tends only to reduce the height of the tool and does not upset accuracy. This wear is minimised as much as possible by making the saddle with long wings.

The headstock mandrel is carried in Timken roller bearings. This feature is somewhat of a departure from usual practice, but the Britannia Company have put the arrangement to prolonged and severe tests, and have found it greatly superior to the ordinary conical bearing in wearing quality and the maintenance of alignment. The two roller bearings are arranged so that the tapers are opposed to one another. These bearings are more expensive than the usual arrangement, but add to an important extent to the accuracy and wearing quality of the tool. The back gear spindle is carried in eccentrics, and the throw-over lever is fitted with an automatic lock. The lever is pivoted at the end of the spindle, and the arrangement is specially designed so that the back gear may be released and thrown in or out with one hand. A sliding block with a spring locating plunger is used for the direct drive and the lathe may be put in or out of direct drive without the use of a spanner. The cone pulleys are arranged for a flat belt and three speeds are provided. The mandrel has a ⅞ in. hole through it, and the nose is 1 in. diameter.

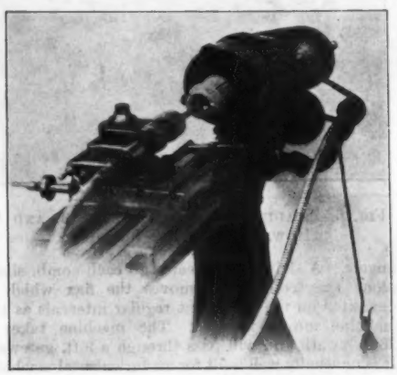


FIG. 3. GRINDING ATTACHMENT.

The tailstock is of the solid pattern and is arranged to set over for taper turning. It is secured to the bed by a bolt at the nearest possible point to the vee guide, thus ensuring accuracy of alignment. The saddle is of large dimensions for the size of the lathe, and is provided with a boring carriage having a number of T slots for holding down work for boring or milling. The boring carriage has a cross-traverse movement which allows of a considerable range of boring and milling work being undertaken. A large apron fitted to the saddle affords good protection for the lead screw. The slide rest is fully compound and is fitted with balanced feed handles. It can be bodily lifted from the boring table by removing four nuts. The table is 5 in. by 8¼ in. The leading screw is 1 in. diameter and has a square thread of ¼ in. pitch. Its thrust is taken on a hardened steel ball. The change wheels are machine-cut from the solid, and permit of all standard Whitworth threads from 1 to 60 per inch being cut. The wheels are fixed on their spindles by a simple spring washer arrangement which allows them to be fixed or removed quickly. Two other detail points which may be mentioned are, that the flywheel runs in ball bearings, and that the tray is of

Fig. 4.

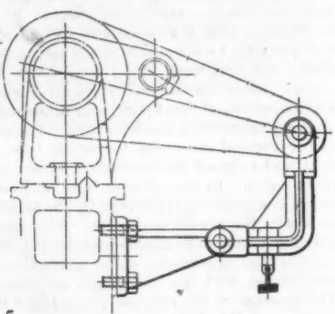
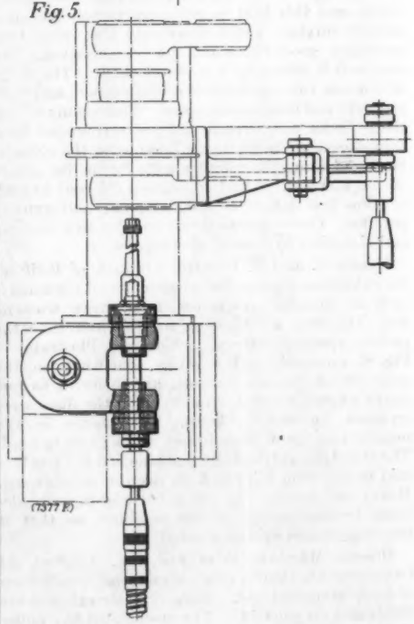


Fig. 5.



ATTACHMENTS FOR 4-IN. FOOT OR POWER LATHE.

CONSTRUCTED BY THE BRITANNIA LATHE AND OIL ENGINE COMPANY, LIMITED, ENGINEERS, COLCHESTER.

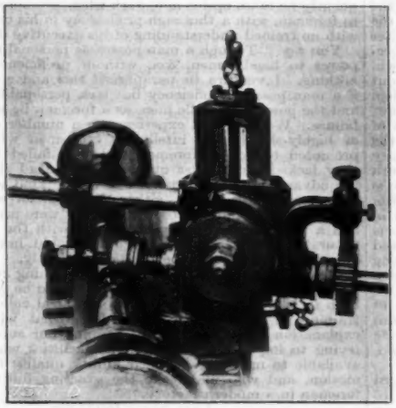


FIG. 6. GEAR-CUTTING ATTACHMENT.

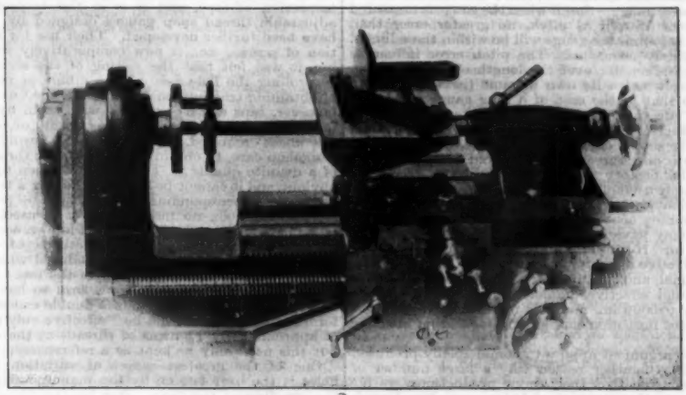
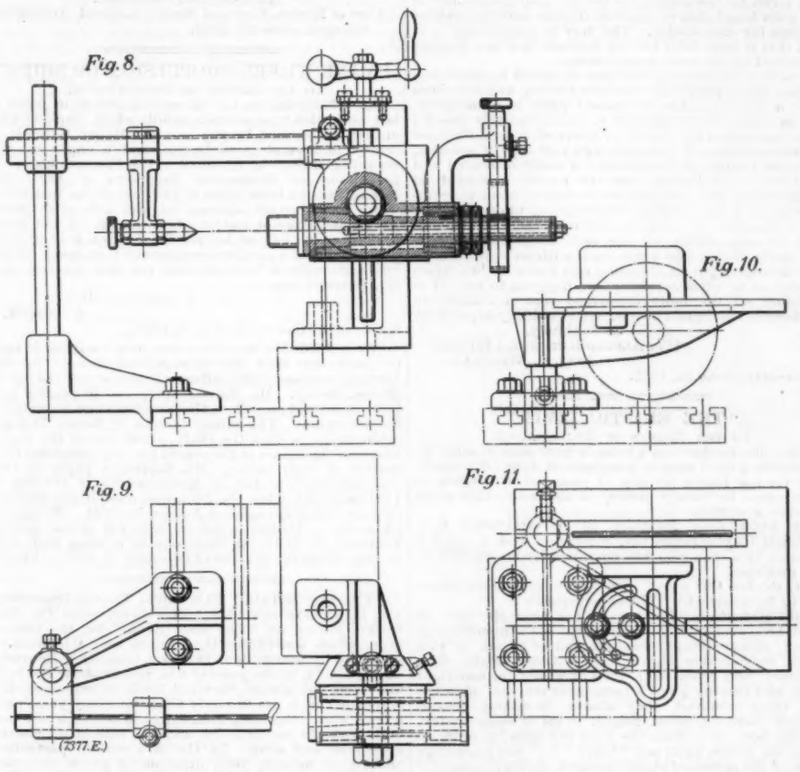


FIG. 7. CIRCULAR SAW ATTACHMENT.



pressed sheet metal. This latter item is usually made of cast-iron, and is generally the first part of a lathe to get broken. The lathe weighs 4¼ cwt.

In dealing with some of the accessory appliances which have been designed for use with this lathe we may first mention that an automatic power-surfacing attachment can be fitted without altering the lathe in any way. This is quite an unusual feature in a lathe of this class. The first appliance which we detail is shown in Figs. 3 to 5. As will be clear from these figures, this is designed to enable grinding to be carried out on the lathe, an internal grinding job being shown in Fig. 3. The whole arrangement will be clear from the figures and requires little explanation. The grinding spindle is carried by a head fixed to the slide rest, and is driven by a flexible shaft from a spindle carried on a pivoted bracket at the back of the headstock. This spindle is driven by belt from the cone pulley and a driving tension is kept on the belt by a spiral spring attached to the pivoted bracket.

A milling and gear-cutting attachment is illustrated in Figs. 6, 8 and 9. As shown, it is arranged for gear cutting, but it will be clear that the vertically travelling slide in conjunction with the cross-traverse of the slide would allow a large variety of milling operations to be carried out. In the gear-cutting arrangement shown the milling tool is carried on an arbour between the lathe centres, and the blank to be worked on is carried by the spindle of the vertically-travelling slide. The outer end of the blank is supported by a centre carried from the horizontal arm, which is supported by the vertical housing and the back vertical pillar. The whole arrangement is mounted in the T slots of the boring table, as is clearly shown in Figs. 8 and 9. The dividing arrangement consists of a plunger carried from the spindle housing and acting in conjunction with a master-wheel. The master-wheel is rotated to the extent of one tooth after each tooth in the blank is cut, and the number of teeth produced on the blank will, of course, equal the number on the master-wheel. It will be clear that instead of the master-wheel a plain wheel with holes in the rim might be used and that the whole arrangement would have great possibilities in the hands of an ingenious user.

The final attachment to which we will refer, and which is shown in Figs. 7, 10 and 11, consists of a small table mounted on the boring table and carrying an adjustable guide plate. It is intended for use in conjunction with a metal saw carried on an arbour between the lathe centres. The whole arrangement will be understood from the figures. These various appliances and others in conjunction with this lathe make a remarkably complete tool which should be of great service not only to amateurs, but in garages and small workshops generally. The lathe is well made and is of good appearance. It is not too light to be serviceable, as was sufficiently illustrated by the remarkable collection of parts made on one of the lathes which we had an opportunity of seeing at Colchester. This included a motor bicycle cylinder 7¼ in. long, a splined shaft 2 ft. long and 2 in. diameter, a cast-iron flywheel 1 ft. 6 in. diameter turned and bored, a 1¼-in. machine tap turned, threaded and grooved, &c. In the case of the 1-ft. 6-in. flywheel the headstock was blocked up to allow of the diameter being dealt with.

"THE PRODUCTION OF ACCURATE SCREW THREADS."

TO THE EDITOR OF ENGINEERING.

SIR,—The writer has followed with great interest the discussion on screw threads and their tolerances, appearing in ENGINEERING, from the first letter by Mr. A. A. Remington up to the latest by Mr. A. H. Sturdee.

The screw thread must be one of the earliest mechanical principles, and it is strange that it should be so misunderstood in an advanced age like ours. That it is misunderstood is obvious to anyone whose experience it has been to examine the manner in which threads are inspected in various engineering shops in the country and the opinions the inspectors have of their accuracy. At first sight it would seem strange that a factory accustomed to making many parts with tolerances of 0·001 in. or so should require the seemingly large tolerances advocated by the British Engineering Standards Association, but this is entirely due to the fact that the methods of gauging and the tolerances of screws have been to a very great extent built up from the conceptions of plain shaft and hole work. It has not been realised that the requirements of screwed work are totally different, and that the methods of manufacture and tolerances can in no way be compared.

Before the advent of limit gauges, it was common practice for a skilled fitter to use a standard plug gauge in a hole that he was producing, and to judge the quality of fit the shaft would have in the hole by the shake of the standard plug gauge. This shake did not convey to his mind that the hole was larger than the standard gauge by a definite amount in thousandths of an inch, but that it was the proper size for the particular kind of fit he required, and it was in judging this that his skill was called into play. While this is possible where a single dimension such as diameter is to be dealt with, no human mind can possibly obtain any idea of the size of a screwed hole by the insertion of a plug gauge and shaking it, or *vice versâ*, by running a ring gauge on to a screw and shaking the screw. Here we have seven different elements to deal with, which, as Mr. Sturdee says, consist of three of diameter (*i.e.*, major, core and effective), three elements of shape (angle, radius at crest, radius at root) and pitch, so that given a man, however skilled, it is impossible for him to have any conception of the true size of either a screw or a tapped hole by means of a single plug or ring gauge.

The tolerances required also differ, in respect that the large number of elements have to be allowed for instead of simply the diameter, as in the case of a plain hole or shaft. In this manner there exists a curious misconception among not only users, but also manufacturers of gauges. It is common to read the specification of a screw gauge maker, and notice that the tolerance

he places on the effective diameter of his gauges is not large enough to include twice the tolerance he places on the pitch error in the length of the gauge. For instance, it is not uncommon to see a tolerance of 0·0003 in. specified as an effective diameter tolerance and a similar tolerance specified as that of pitch; the maker, and as often the user, imagine that if when the gauge is measured on diameters as well as pitch, no greater error than 0·0003 in. is found, the gauge will be within these limits. This is entirely erroneous. The pitch error influences the effective diameter over the length of the gauge by approximately twice its own amount (in a Whitworth thread), so that in the case of a plug gauge where the compound effective diameter (*i.e.*, the effective diameter over the length of engagement) must not be larger than nominal, the simple effective diameter (*i.e.*, the effective diameter of one thread as measured with National Physical Laboratory needles) must be reduced by approximately 0·0006 in. to allow for the pitch error, and if in addition we have a further tolerance of 0·0003 in. for the accuracy of form of the effective diameter itself, the gauge may have a total effective diameter tolerance of 0·0009 in. If on checking the gauge it were found that the effective diameter was not more than 0·0003 in. below nominal, and the pitch error still the same amount, the compound effective diameter might still be above nominal by 0·0006 in., and this would not be apparent by any direct measurements on any measuring machine whatever.

The same argument applies to commercially-produced screws, and is another reason why a large number of engineers imagine that their screw productions are far more accurate than they need be or are. The British Engineering Standards Association, in compiling their tolerances did yeoman service, but the greatest handicap which they suffered was the fact that no commercial system of gauging screws existed which would enable manufacturers to produce their work to the tolerances laid down.

The ring gauge in universal use during the war has practically no virtues, while its faults are legion. Its short life, variation of form as well as dimension, due to wear, high cost both of purchase and upkeep, coupled with absolutely negative results, that is, the passing of screws of a far inferior quality to those accepted, has led manufacturers who were forced to use this system during the war into a general mistrust of gauging screws at all. It has given them the opinion that the gauging of screws is something to be avoided, and under the conditions in which their opinion was formulated, it is not surprising.

The shortcomings of the ring gauge were evidently recognised by the A.I.D., where in cases of great importance a "not go" effective only-ring gauge was advocated as well as the full form "go." Consisting as it had to of only one or two turns of thread, and having to be forced over burrs on the commencement of screws which had been caused by dropping or banging in boxes together, its life was even shorter than that of the full form gauge, and as its life shortened due to wear, so the tolerance on the work decreased, till the production of screws to pass these gauges became the bane of the shopman's life. Numerous devices were brought forward to overcome these defects, amongst the most important systems to be turned to commercial use was that of the projector. This machine, while outclassing the ordinary ring gauge in every way, still has several difficulties and shortcomings.

The projection system can be roughly divided into two classes. Firstly, that in which the complete image of the screw is thrown on the screen and the number of threads in the length of engagement tested against a master template. This has the disadvantage that with the standard magnification of 50 times, even using a very large field, the length of engagement tested cannot be much over ½ in., and for lengths of engagement larger than this, the pitch error has to be taken for granted as uniform and the compound effective diameter over the complete length of engagement calculated, so that the assemblage of the screw is left to chance. It is also difficult to support the screw from the threads alone, since in a large number of cases, the threads are not long enough, and when a supporting element such as a shank is introduced the errors on this influence the reading.

The second system consists of locating one end of the screw by its thread and testing the position of the last thread in the length of engagement. This again relies on a perfect progressive pitch error which unfortunately rarely, if ever, exists. The pitch error, especially in taps, is extremely erratic, and in order to know that the screwed article will definitely assemble, the full length of engagement should be tested, that is, every thread between the first and last threads in engagement, it being quite possible to have a screw which comes nearly back to zero in its length of engagement, but which has a large pitch error in between. The supporting of the screw is difficult just in the same way as the former case. With taps, the slight taper for clearance from the front to the back also influences the results.

Another difficulty with the projection apparatus is that while helping the inspector, it does not necessarily aid the man setting up the machine. It is important that scrap should not find its way into the stores. It is more important that scrap should not be made. It is clear that the setter-up requires identical means for testing his product as that used by the inspector afterwards, otherwise the machine is not set up on the proper end of the tolerances, and has to be set up more frequently, with a consequent loss of production and a large increase in the percentage of scrap.

A factory usually turns out screws of many different diameters and pitches, and to use this system for setting-up and inspection means the installation of several machines, with consequent cost and loss of floor space. If only one or two machines are installed, the setter-up usually has to wait and therefore loses production.

The projection system is also useless for large work, involving bolts and studs of 12 in. up to 35 ft. in length, and up to 4 in. in diameter, as met with in Diesel engine construction, and also for pipe and many other general pump and engine screw parts.

Both Mr. Remington and Mr. Sturdee mentioned the inspection of taps, and it is in this respect that the adjustable thread snap gauges designed by the writer have been further developed. Their use for the inspection of screws, &c., is now comparatively well known, but it was felt that the testing of the screw without controlling the hole was a mere nibble at the problem of obtaining true interchangeable threaded work. Now, however, taps can be classified with them by means of unskilled labour, as falling either inside or outside the tolerances required. It is possible, using ordinary workshop care, to obtain interchangeable threaded work of a definite quality. That taps are open to misuse is obvious, and it cannot be said that having a tap of given accuracy a corresponding accuracy will be produced in the tapped hole, no matter how it is used, but it is possible to say that having a tap of known accuracy and using ordinary good workshop methods of producing the tapped hole, a hole will be produced which bears a definite relation to the accuracy of the tap.

It will be still advisable for a firm to have a set of reference gauges in the form of a double ended plug, full form at one end and "not go" effective only (consisting of approximately 1½ turns of thread) at the other end, but this need only be kept as a reference.

One of the greatest causes of variation in tapped holes is the burr left on by tap manufacturers, due to the grinding of the flutes after hardening. This burr, while not easily visible by either measurement or projection, can instantly be felt in the delicate knife-edge test given by the adjustable thread snap gauges, and it has been found that on removal the size-cutting qualities become far more stable. The burr in many cases is so stiff that it lasts until the tap becomes dull and is again generated on the next re-sharpening.

The time and money that can be saved by the introduction of a system like this in a factory which handles even a small number of screwed parts is tremendous, but in spite of that difficult to prove, for this reason: It is comparatively simple to prove to a manufacturer the saving obtained in employing a new type of machine, since the output of the machine is easily measured and its labour cost known, but the money expended on badly-fitting and scrapped screwed parts is an expenditure which is spread over a large number of departments and is therefore not easily realised or traced. This makes such an expenditure all the more dangerous, since it can easily double and treble itself without appearing as any alarming figure in the costs, and throw no indication exactly as to what its true cause happens to be. It is therefore all the more important that a leakage so insidious as this should be rendered as unlikely as possible.

Yours faithfully,
(For ALFRED HERBERT, LIMITED),
AXEL C. WICKMAN.

Coventry, June 21, 1922.

"THE ELASTIC LIMIT."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Roxbee Cox's letter in your issue of June 30, commenting upon mine in your issue of June 23, scarcely calls for my taking up any of your valuable space in reply, since he merely shows, in the main, that what I stated is correct.

My letter drew attention to an established fact, established by experiments, conducted over a number of years, by a man who was renowned for his carefulness and precision.

Mr. Roxbee Cox says "The bulk of experience shows this to be incorrect." Whose experience?

Bald statements like that do not alter the fact (of which he is evidently not aware) that in the manufacture of, say, helical springs, these are first of all set up, to a height considerably above their finished height, then hardened, and tempered; then they are pushed right home, and thereby given a permanent set, and upon the load being removed, they almost invariably remain at their correct finished height. This is done to-day, and has been done since the good old days, in order to lift up the elastic limit, not "lower" it, "and advantage taken of the increased elastic strength thereby induced."

If people would only observe, and try to understand established facts, instead of trying to explain them away, in favour of some pet theory of their own, which is unsupported by facts, then, all the confusion that matters would very soon be eliminated, and the remainder would eliminate itself.

Yours faithfully,
July 4, 1922. "CONVINCED."

"THE EDUCATION OF THE WORKER."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with much interest your leading article on "The Education of the Worker," in ENGINEERING for June 23. I quite agree with you that proficiency is a necessary qualification for foremanship, now as in the past. In the "Report on Training for Foremanship" mentioned in the seventh paragraph of your article, the importance of this thorough manual competency is recognised; the passage on "The Organising Foreman" begins "Whilst still usually selected for superior craftsmanship . . ., &c."

But we think that under modern factory conditions talent for organising is more necessary in the foreman than it used to be, and therefore we urge that men should be definitely trained for executive duties before undertaking responsibility for them.

The foreman of to-day gets a thorough training in craftsmanship and, by evening study in technical classes can acquire a good theoretical knowledge of subjects related to his craft, but he is not taught in the works how to organise or supervise, and he cannot get systematic instruction in these subjects in the evening. Consequently he takes up his new work when promoted to act as foreman, with a thorough proficiency in his craft, but with no trained understanding of his executive duties.

You say, "Though a man possesses personality, tact, power to handle men, &c., without proficiency he is nothing. I venture to paraphrase this and say that, if a man possess proficiency but lack personality, tact, and the power to handle men, as a foreman he will be a failure. We have had experience in a number of cases of highly-skilled and intelligent craftsmen who were promoted to act as foremen and who failed because they lacked these other qualifications. Had they had the advantage of specific training of the kind which is advocated in the report, either their lack of aptitude would have been discovered before they were promoted, and a mistake have been avoided, or with the help of natural aptitude and training they would have been able to undertake their new duties efficiently.

We do not advocate a less thorough training in craftsmanship, but urge that opportunities should be provided both in the workshop and in the technical colleges for training in executive work. I hope that with this explanation we may count on having your support in trying to improve the educational facilities which are available to men who by their ability qualify for promotion, and who undertake the exacting duties of a foreman in a modern factory.

I am, yours faithfully,
NEIL J. MACLEAN,
Chairman, the Association for Education in Industry and Commerce.

Care of Messrs. Barr and Stroud, Limited, Anniesland, Glasgow, June 29, 1922.

"VANE WHEEL PROPULSION OF SHIPS."

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the interesting article in yours of last week, this type of screw paddle wheel, single or twin at stern, was used by the late Mr. Henry Barcroft at Newry in several canal barges, and a paper by him regarding them may be found in the Proceedings of the Institution of Mechanical Engineers of 1894. Mr. Barcroft read a later paper in 1897 before the Institution which gave further information and also observations on the influence of section of waterway. I had about that time, but cannot lay my hands upon it at present, illustrations of a similar arrangement very much earlier, but apparently it had not been put into practice until Mr. Barcroft used it.

Yours faithfully,
W. SISSON.

Hucclecote, Gloucester, July 4, 1922.

[We publish Mr. Sisson's letter, but we think it right to point out that the arrangement devised by Mr. Barcroft was essentially different from that carried out by Messrs. Denny. Mr. Barcroft proposed to employ partially immersed propellers, the propeller shaft being below the water-line. The salient feature of Messrs. Denny's arrangement is that the shaft is well above the water-line, and the blades of the screws are only immersed for a portion of their radius. Mr. Barcroft's paper of 1894 was published in full in ENGINEERING of October 5, 1894, page 468, while the discussion upon it was reported on page 188 of our issue of August 10, 1894. His second paper was published in full on page 295 of our issue of February 27, 1897, the discussion on it being dealt with on page 200 of our number of February 12, 1897.—ED. E.]

"THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK FOR 1922.—This directory of *The Electrician*, known as "The Blue Book," for the current year, which constitutes the fortieth annual edition, is published by Messrs. Benn Brothers, Limited, 8, Bouverie-street, E.C. 4, at the price of 25*s.* net, is about the best-known of the annual electrical books of reference, and it remains, as it has formerly been, for many years past, a book most frequently referred to in offices which deal both with the construction and the sale of all electric apparatus and work. In the first section particulars relating to patents, fees, duration of grant, &c., also numerous technical tables and data are given. The directory section has been revised and extended by 50 pages, the chief extension being in the alphabetical and the classified sections. The present edition covers a total of over 1,350 pages, reference to which is greatly facilitated by thumb indexes.

BRITISH CHAMBER OF COMMERCE IN BELGIUM.—Owing to the gradual and steady development of this Chamber since the war, the council have decided to publish a quarterly journal, with the object of rendering still greater service to the British commercial community in Belgium. The publication will bring the members into closer touch with each other. The first issue of this journal is dated May, 1922; it gives particulars of the annual general meeting held on January 20 last, and other information for facilitating British trade with Belgium. The hope is expressed that members will contribute original articles likely to be of use to other fellow-members. The list at the end gives an indication of the number of British firms who are already trading with Belgium. A recent stay in that country has revealed to us the activity of Belgian concerns; we trust that co-operation between them and firms on this side will greatly extend in the near future to the benefit of both. The journal, we may add, is admirably printed, and its get-up reflects great credit upon the Council of the Chamber.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Progress is somewhat impeded by half-yearly stock-taking operations, but inquiries at representative steel and engineering works clearly show that there has been a marked strengthening of the undertone since the settlement of the engineering dispute. This is confirmed by the fact that since the keymen returned something like 10,000 skilled and semi-skilled operatives have been absorbed into the heavy trades of Sheffield, leaving the total of those unemployed and on short time round about 40,000. For obvious reasons the market for raw and semi-finished materials is attracting increasing attention. Stocks at manufacturing works of all descriptions have been kept down to the minimum during the recent paucity of new business. Increased buying of finished products is now reflected in a livelier inquiry for steel billets, hematites, and pig-iron. More iron is coming into this district from northern areas under contracts recently placed, while the output of basic and semi-finished steel is expected to show a marked expansion within the next two or three weeks. More steel furnaces will be in operation by mid-July than at any period during the last three or four months. The maintenance of cut prices for iron and steel of all grades is responsible for a bigger percentage of home and export inquiries materialising in solid business. Much of the work that is now being undertaken allows little or no margin of profit, but is paving the way for better things in the near future. Local rates are uniformly below those quoted by Belgian and German competitors. The latest quotations are as follow:—Siemens acid billets, 10*l.*; Bessemer acid billets, 12*l.* 10*s.*; hard basic billets, 8*l.* 5*s.*; soft basic billets, 7*l.* 15*s.*; West Coast hematites, 5*l.* to 5*l.* 5*s.*; East Coast hematites, 4*l.* 17*s.* 6*d.* to 5*l.*; Lincolnshire No. 3 foundry, 4*l.* 5*s.* to 4*l.* 7*s.* 6*d.*; Lincolnshire forge, 4*l.* to 4*l.* 2*s.* 6*d.*; Derbyshire No. 3 foundry, 4*l.* 2*s.* 6*d.*; Derbyshire forge, 3*l.* 17*s.* 6*d.*; bars, 12*l.* to 12*l.* 10*s.*; and sheets, 16*l.* to 17*l.*, all delivered at Sheffield. Shipbuilding engineers are negotiating a period of considerable anxiety. Lord Aberconway described the last twelve months as the worst in his experience of the operations of Messrs. John Brown and Co., Limited. Signs of improvement are not wanting, but it is not expected that material headway will be registered before January next. Makers of special steels are doing a rather better trade with automobile and agricultural engineers, but order books are a long way from being satisfactory. Special action is to be taken to combat proposed increases in Italian tariffs, which would further hamper an already harassed section of local industry. Encouraging signs are to be found in the lighter trades. It is anticipated that the price cutting which has been such a prevalent feature among manufacturers of certain classes of tools will become less pronounced as more stable conditions are restored. Substantial orders have been booked for hand saws, circular saws, twist drills, and joiners' tools, and inquiries on home and Colonial account are in circulation for mining and quarry tools, and files.

South Yorkshire Coal Trade.—The latest reductions having failed to stimulate business in house coal, merchants are trying to induce more active conditions by advising consumers to get in winter stocking operations rather earlier than usual. Few of the house coal pits are working more than three days a week. Business in best steam hards is moving steadily on home account, with a fair demand for locomotive purposes. Despite the handicap of high railway rates as compared with competing districts, Yorkshire coal owners have booked big business with Norway, covering deliveries over the next two months. Best slacks for coke-making are in short supply at firmer rates; foundry coke is in fair demand; exports are on a moderate scale; Gas coke is still on the weak side. Quotations:—Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

ROYAL SANITARY INSTITUTE.—The thirty-third Congress of the Royal Sanitary Institute will this year be held at Bournemouth, and will extend from the 24th to the 29th inst. The work of the congress will be dealt with in sections and in conferences, in addition to which lectures and various functions figure on the programme. The section with which our readers are most concerned is, probably, B, Engineering and Architecture; while Conference III will be of interest to engineers and surveyors to county and other authorities. On Monday, the 24th, there will be a public luncheon in the Town Hall, when members will be received by the mayor, who subsequently will open the health exhibition in connection with the conference. At 5 p.m., Major-General the Right Hon. J. E. Seely, C.B., C.M.G., D.S.O., will deliver an inaugural address. On Tuesday sectional meetings will be held, and Conference III will be taken. After excursions in the afternoon a lecture will be given at 8 p.m. by Professor L. Hill on the "Value of Clean, Fresh Air." On Wednesday, sectional meetings will be held in the morning; visits and excursions are planned for the afternoon and a *conversazione* for the evening in the Town Hall. On Thursday morning there will be meetings (including one of Section B), excursions in the afternoon and a special concert in the evening. On Friday meetings and excursions are arranged, with the congress dinner in the evening. Excursions are arranged for Saturday. The full programme and particulars may be obtained from the Secretary, 90, Buckingham Palace-road, S.W. 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues on only a moderate scale. Home demand is disappointing, though, if anything, it is a little better, and Continental buying falls a good deal short of what could be wished. American inquiries are still circulating both for special kinds and for ordinary foundry iron, and further sales to the States are expected to be made. No. 1 and siliceous quality continue scarce, and are firm at 95*s.* Other descriptions are quite plentiful, but values are well maintained at: No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.* The foregoing quotations were f.o.t. makers' works, or f.o.b. Tees, and ruled for all home and export transactions except sales to Scotland, which were conducted on the basis of 96*s.* 8*d.* f.o.t. Grangemouth for No. 3.

Hematite.—The hematite situation is practically unchanged. Supply continues a good deal more than ample, and this enables customers to hold off and make purchases just as they need the iron. There is some forward inquiry, however, and makers speak hopefully of early increase in demand. Nos. 1, 2 and 3 range from 93*s.* to 95*s.* There are producers who will not entertain offers at below the latter figure, but buyers declare that they can place orders to meet their requirements at the former quotation.

Foreign Ore.—Sales of ore, beyond disposals of odd cargoes, are hardly heard of. Doubtless sellers would readily consider favourably offers at substantially below the general market quotations of 27*s.* c.i.f. Tees for best rubio, and 23*s.* 6*d.* for good Mediterranean ores.

Coke.—Blast-furnace coke is stiffening. Whilst local consumers state they can still buy average Durhams at 26*s.* 6*d.* delivered, several sellers are now holding out for 27*s.*

Manufactured Iron and Steel.—Expansion of operations at the various works is very slow, and a great proportion of plant continues inactive. Export contracts can be made at a good deal below the following quotations for home trade:—Common iron bars, iron rivets, 13*l.* 10*s.* to 14*l.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 10*l.*; heavy steel rails, 9*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 16*l.*

Imports of Iron and Steel.—Tees conservancy Commissioners' figures issued this week show that for the eight months ending June 30 last, 32,552 tons of pig-iron arrived at the ports of Stockton and Middlesbrough from Holland, Belgium, France, Norway, Sweden, Germany, and coastwise, as compared with 17,240 tons for the same time a year ago, and 218 tons for the pre-war period ending June 30, 1914. Sheets, bars, billets, blooms and slabs brought to the Tees from the countries named, during the past eight months reached 41,218 tons, as against 17,201 tons a year ago, and 30,507 tons for the period ending June 30, 1914. Plates, bars, rails, sheets, hoists and angles imported to the Tees in the past eight months are given at 4,229 tons, as against 16,641 tons a year ago, and 17,419 tons for the corresponding months just previous to the outbreak of war.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The state of the Scottish steel trade shows no change over the week, and rolling mills are still moving intermittently. There has been little improvement in demand, as buyers are very reluctant to book ahead, and commitments are on a small scale. Inquiries all round are somewhat better, and it is hoped that before long some respectable orders will be given out, but all the same there is a want of confidence, and until that condition passes off business can only be carried on with difficulty. The holiday season has now commenced in the lower reaches of the Clyde, and next week the works in Glasgow and district close down for the annual Fair Holidays, but this year there is no rush for deliveries before the stoppage. The improvement in the outlook generally continues, and it is freely expected that when the holidays are over business will steadily get better and the demand will increase. Shipbuilders are not getting through many plates at present, but the consumption of steel by locomotive builders will get a little better on account of some satisfactory orders recently fixed up. Black sheet makers are moving slowly and do not report any change in position. The general export trade is still very poor, as foreign buyers are very conservative in committing themselves meantime, as they are hopeful of securing better terms before actual necessity forces them into the market. Prices show no change, and are all round last week's quotations.

Malleable Iron Trade.—The West of Scotland malleable iron makers are not in a very satisfactory position at the present time, as the bulk of the plant is lying idle. The hopes of a revival in demand have so far come to nothing, and little is expected now until after the holiday season is over. Order books are very bare and actual tonnage is small. At the end of last week a reduction of 10*s.* per ton, for home delivery, was decided upon by producers and "crown" bars are now called 10*l.* 10*s.* per ton delivered Glasgow. This reduction is expected to stimulate dealing, but actual consumers are themselves hard up for business and do not feel inclined to place orders at the moment.

Scottish Pig-Iron Trade.—Business in the Scottish pig-iron trade is, if anything, the turn quieter this week, but the tone of the market keeps strong. The settlement of the labour disputes has considerably improved the prospects, and a fair amount of dealing has been carried through recently. Prices continue to show a hardening tendency, and that has given consumers more inclination to place orders. As the general trade outlook is better, there is every possibility of a larger number of furnaces being in blast by the early days of August. At present the total number is 16, all of which except one are on foundry iron. The current prices are:—Scottish hematite, 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, both on trucks at makers' yards.

Scottish Shipbuilding.—The output of new tonnage from the various Scottish shipbuilding yards during the month of June was 18 vessels of 38,421 tons, which compares with 25 vessels of 42,651 tons for the same month of last year. The total for the six months of this year was 75 vessels of 180,273 tons, as against 155 vessels of 275,369 tons for the corresponding six months of last year. The falling-off is considerable, amounting as it does to over 95,000 tons, but there have been several causes for the poor returns this year. First of all there was almost no demand for new vessels, owing to the low state of general trade throughout the world, then there were high wages to contend with and consequently high cost of construction, which placed new tonnage on a non-paying basis for shipowners. Labour disputes were another factor in the situation, the principle of them being the strike of shipyard workers and the lock-out of the engineers. Now that these troubles have been surmounted and the men are being absorbed as quickly as conditions permit, the outlook is certainly becoming much clearer, and there are hopes of buyers again entering the market in the near future. A number of inquiries are now under consideration, and there are good prospects that these may result in orders before long.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—It will be recalled that at the annual conference of the South Wales Miners' Federation last week it was decided to delay 14 days over the non-unionist question, to commence from July 10. The Executive Council of the Federation have now decided to postpone the giving of notices for a week on the grounds that the annual conference of the Miners' Federation of Great Britain would be held on the last week prior to the expiration of the notices and that it was considered advisable that at such a critical moment all the men's leaders should be in their respective districts to deal with the situation before the expiration of the notices. The certificate of the joint accountants showing the proceeds and costs in the Welsh coal trade in May, upon which the July wages are based, shows that the industry can afford to pay only 23·23 per cent. above the 1915 standard rates. As the minimum under the national settlement is 28 per cent. the owners are called upon to sacrifice about 26,000*l.* to make up the workers' minimum. The results attained in May are the best since November last, due to a slight increase in selling prices, and an improvement in the volume of exports and in production. Outputs were about 870,000 tons higher than in April, and as a result the cost of production was reduced by 1*s.* 5*d.* per ton, of which the wages cost was reduced 2*d.* The outlook for the June return, however, is not too bright, as it is practically certain that the May result will not be maintained, for production was reduced and selling prices lowered in consequence of a falling-off in the foreign demand. In fact, at the end of the past month values were on the basis of 25*s.* 6*d.* for best Admiralty large and 17*s.* for best steam smalls, a reduction of 3*s.* and 2*s.* respectively on the price ruling in May. Since then there has been a further reduction, and it is now possible to secure best Admiralty large at 25*s.* and best smalls at 16*s.* 6*d.* when taken together, with other grades at relative figures. Even these prices have not attracted trade, and at present temporary pit stoppages are numerous. Exports, however, have been fairly well maintained as the result of the shipment of quantities contracted for some time ago. Last week foreign shipments amounted to 501,000 tons, of which 155,200 tons went to France, and 137,600 tons to unclassified countries, which include Scandinavia, Russia, Germany, Holland and Belgium. The coal-owners have been considering the question of stabilising prices, and it is reported that certain proposals have been agreed upon by which it is hoped selling prices will be stabilised and unnecessary reductions prevented. Buyers generally, however, are of the opinion that demand is the only thing that can stabilise values.

Iron and Steel Trades.—The export demand for Welsh tin plates shows an improvement, but the home inquiry has slackened. Manufacturers are stated to be fairly well booked up over the next couple of months and are asking higher prices for new business. A new pooling arrangement, under which orders are divided amongst the different works, came into operation on Monday. For standard boxes prices are steady at 19*s.* 6*d.* to 20*s.* There was an improvement in the volume of exports last week. In all, 17,700 tons of iron and steel goods were shipped from South Wales or double the quantity exported in the previous week. Of the total, 10,118 tons comprised tin plates, 4,207 tons iron and steel, 2,159 tons galvanised sheets, and 1,270 tons black plates.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Through the courtesy of Messrs. Alf Cooke, Limited, a visit has been arranged to their Crown Point Printing Works, Leeds, for Saturday, July 15, 1922. Train leaves Keighley, M.R., 1.39 p.m.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

(*For Description, see Page* 11.)

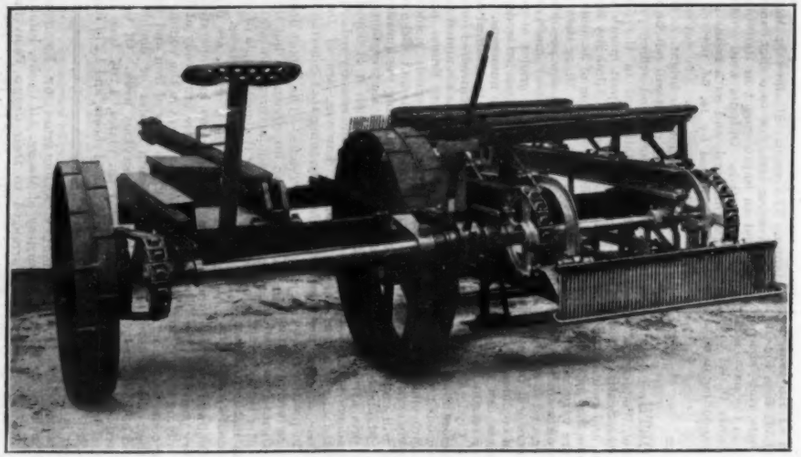


FIG. 7. MECHANICAL FLAX PULLER.

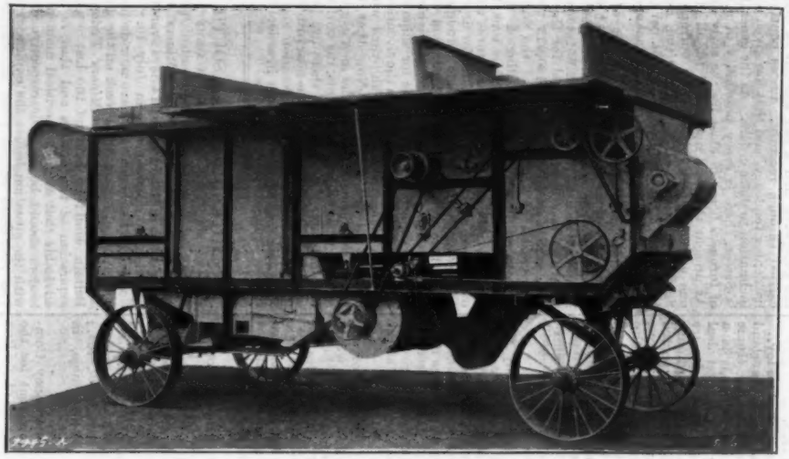


FIG. 9. ALL-STEEL THRESHING MACHINE.

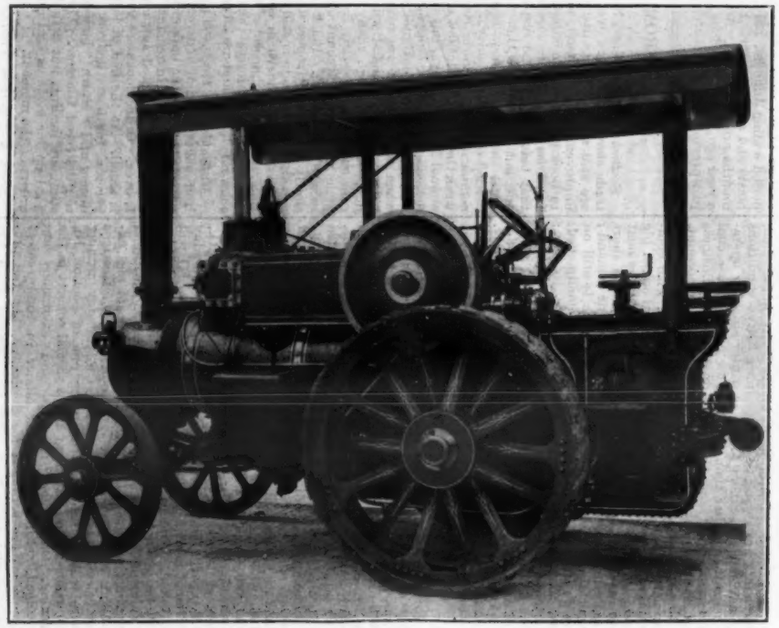


FIG. 8. COMPOUND STEAM TRACTOR.

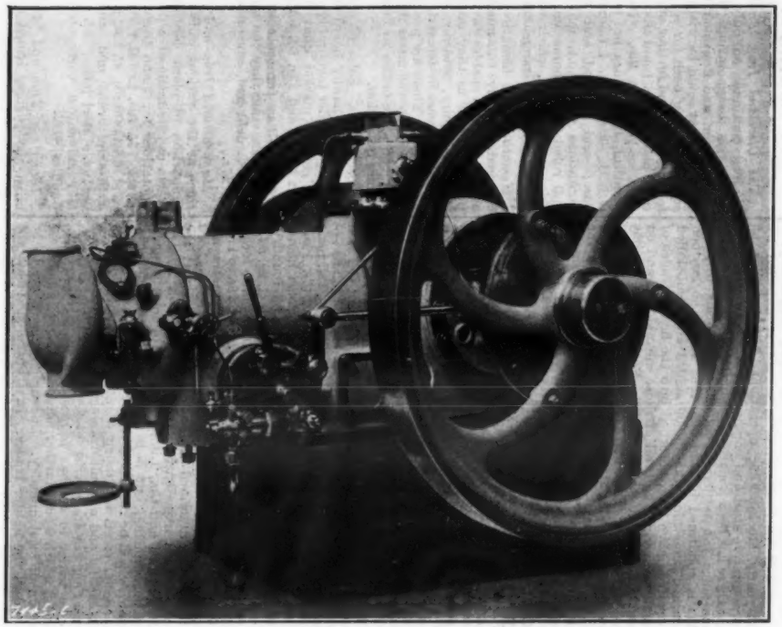


FIG. 10. 8-B.H.P. FIXED OIL ENGINE.

THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

(*For Description, see Page* 3.)

FIG. 15. THE PALM COURT FOR FIRST-CLASS PASSENGERS.

(*To face page* 4.)

FIG. 10. 8-B.H.P. FIXED OIL ENGINE.

FIG. 8. COMPOUND STEAM TRACTOR.

THE WHITE STAR QUADRUPLE-SCR

(For Description, see Pa

Fig. 2. ELEVATION

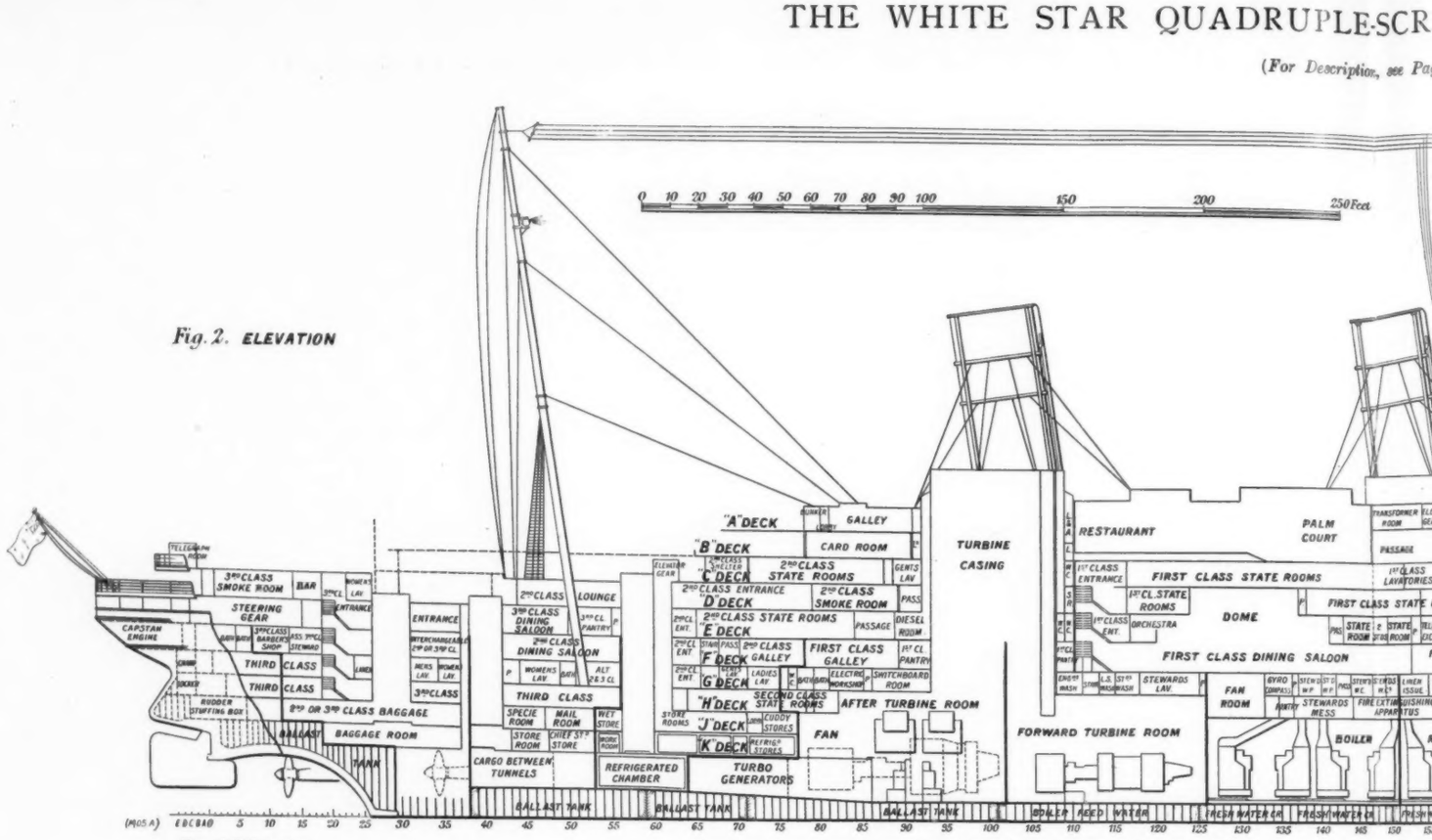


Fig. 6. "C" DECK.

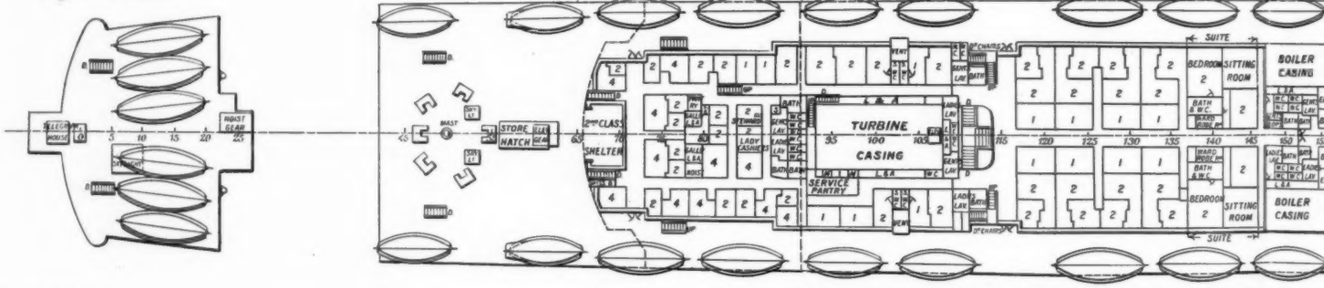


Fig. 7. "D" DECK.

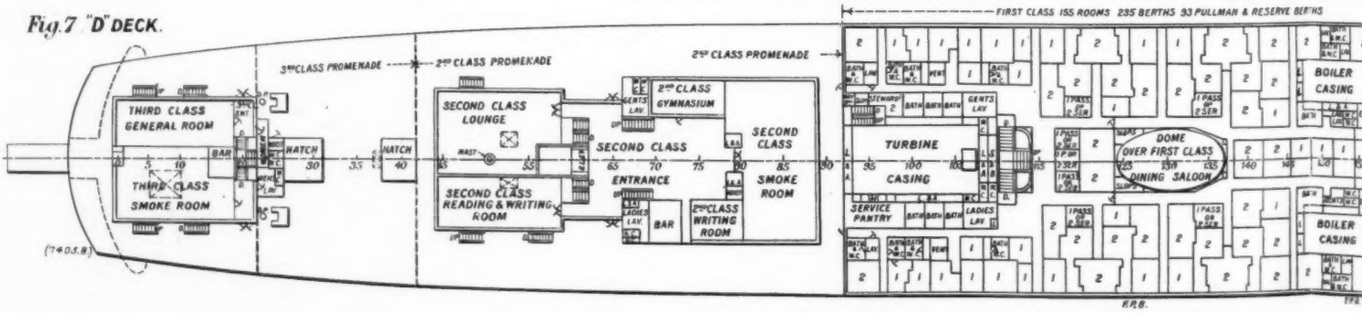
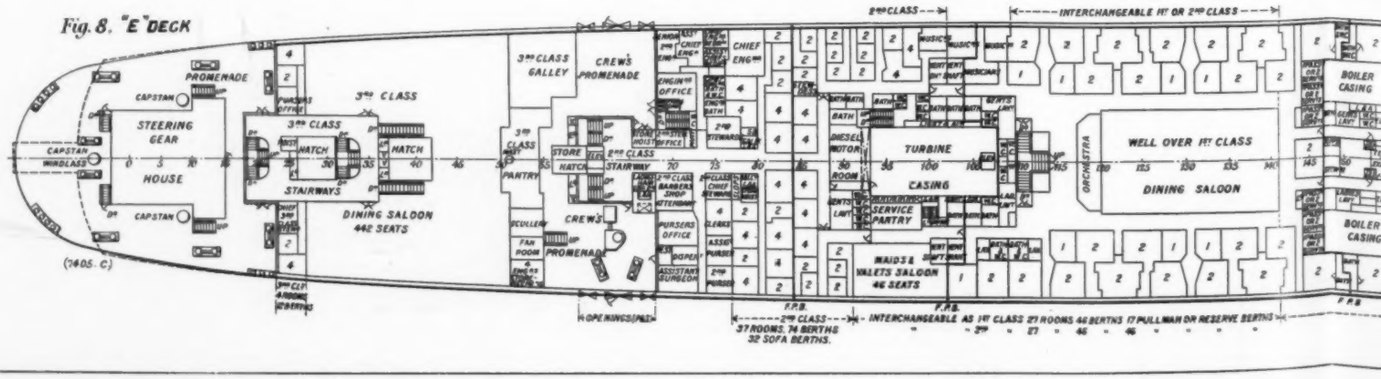
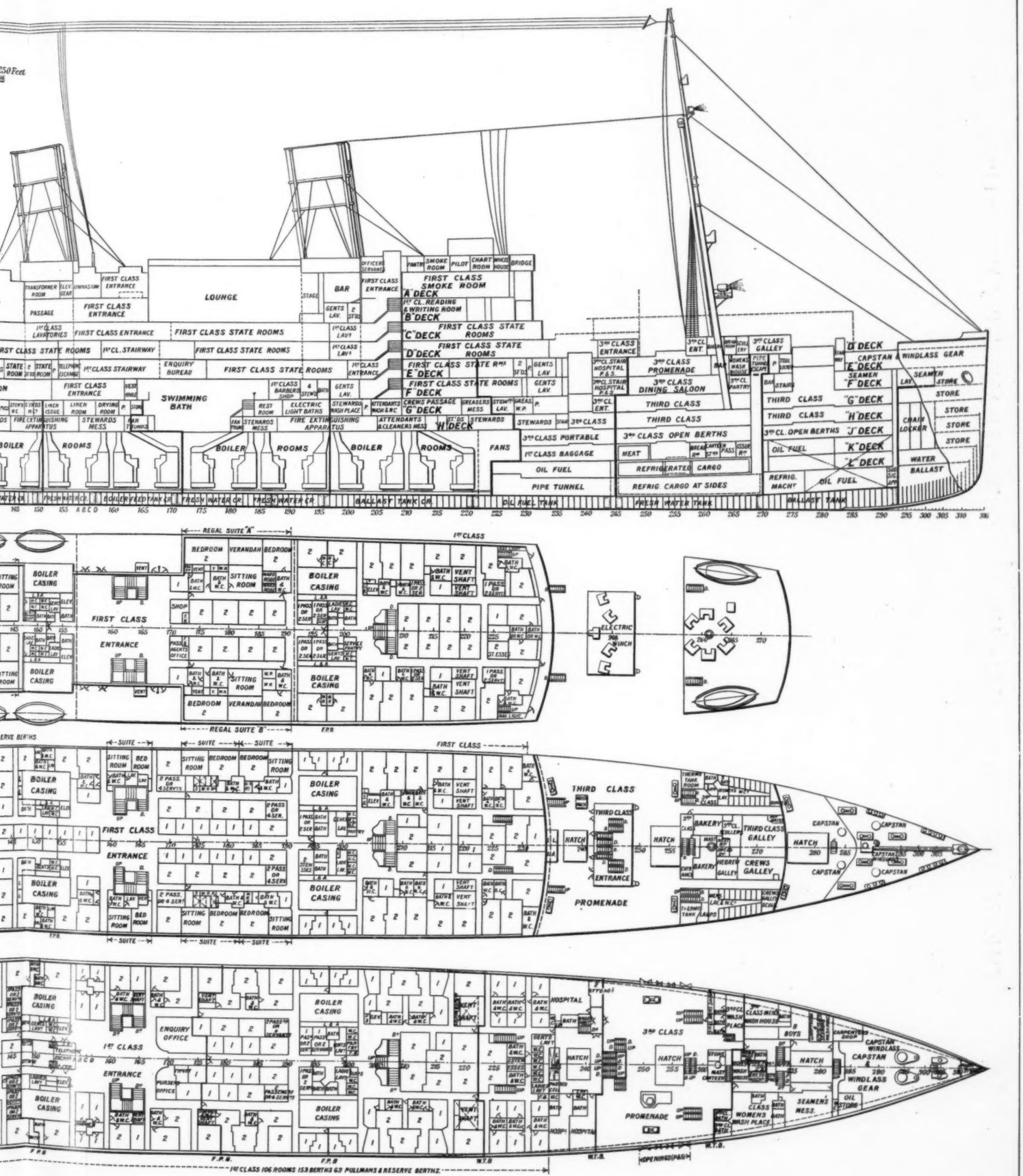


Fig. 8. "E" DECK



LE-SCREW STEAMSHIP "MAJESTIC."

(cription, see Page 3.)



THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

(*For Description, see Page* 3.)

FIG. 16. LOUNGE FOR FIRST-CLASS PASSENGERS.

THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

(*For Description, see Page* 3.)

FIG. 17. VIEW IN DINING SALOON FOR FIRST-CLASS PASSENGERS.

FIG. 18. READING AND WRITING ROOM FOR FIRST-CLASS PASSENGERS.

THE WHITE STAR QUADRUPLE-SCRE

(For Description, see Pag

Fig. 9. "F" DECK

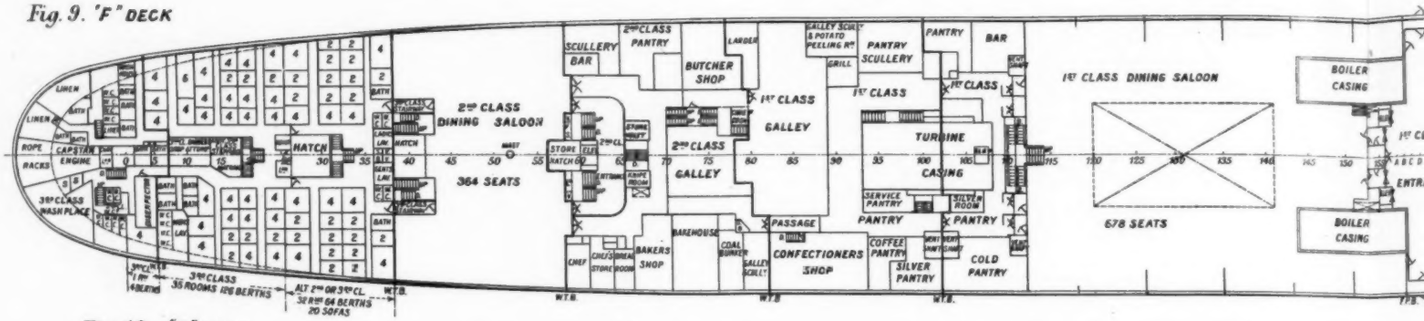


Fig. 10. "G" DECK

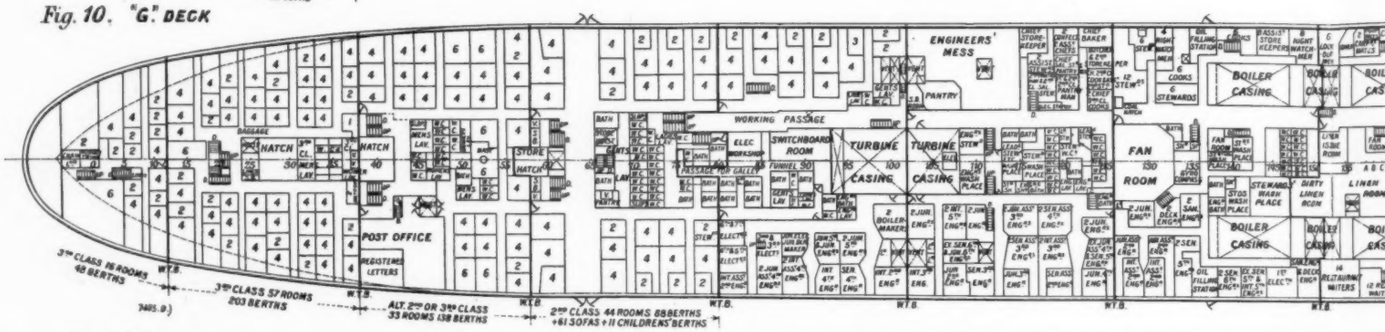


Fig. 11. "H" DECK.

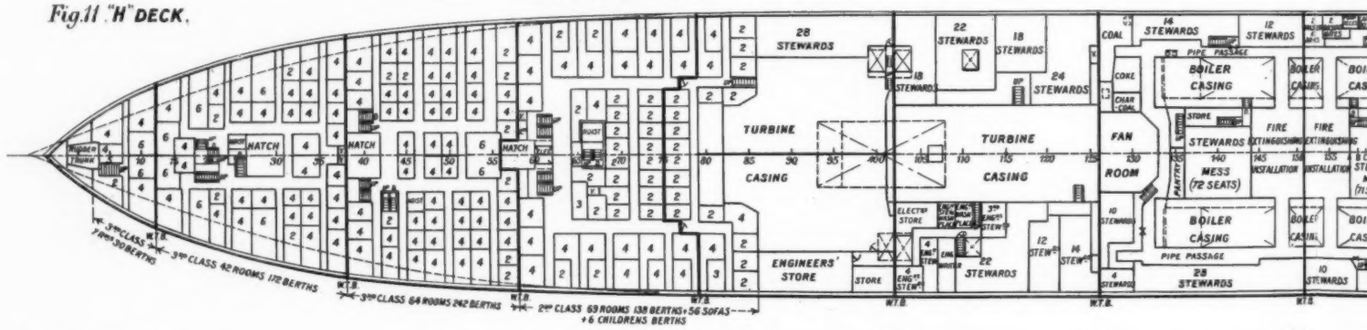


Fig. 12. "J" DECK.

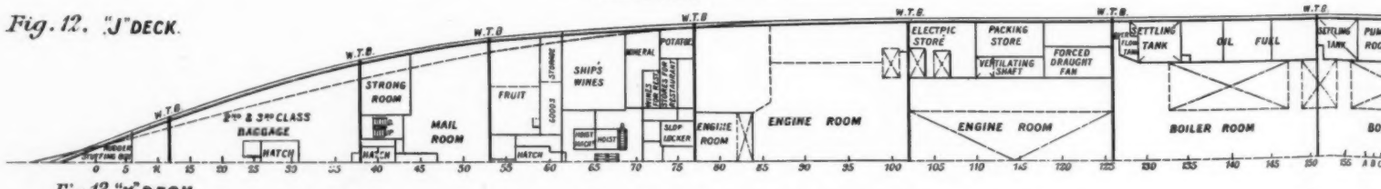


Fig. 13. "K" DECK.

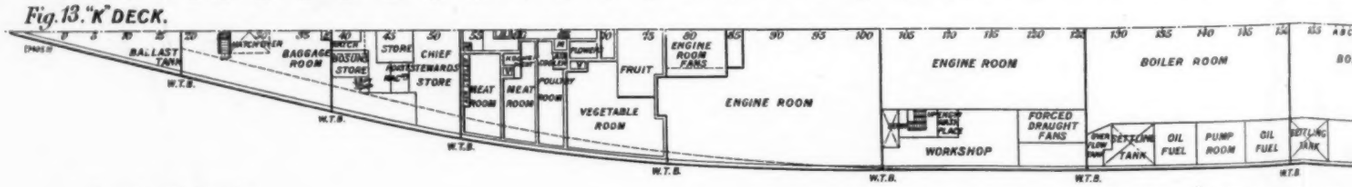
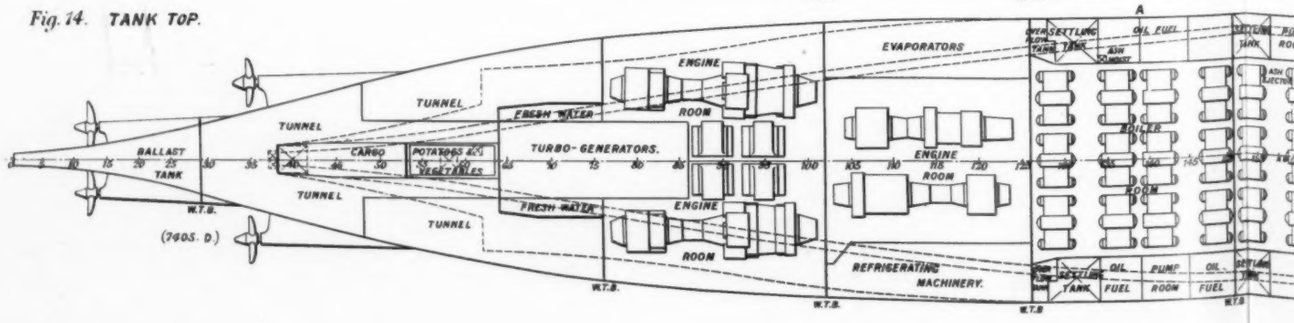
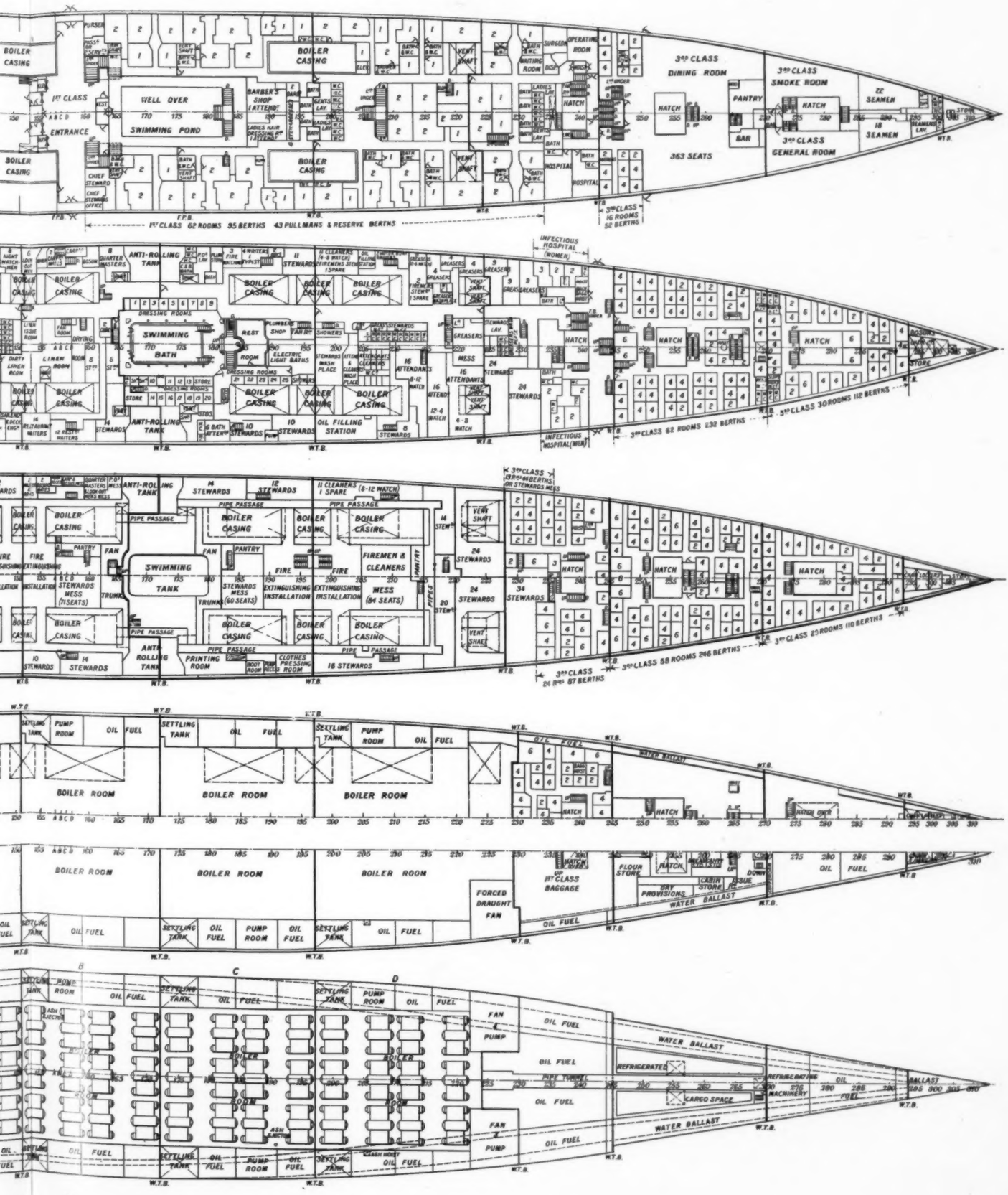


Fig. 14. TANK TOP.



LE-SCREW STEAMSHIP "MAJESTIC."

(*ription, see Page* 3.)



THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."

(*For Description, see Page 3.*)

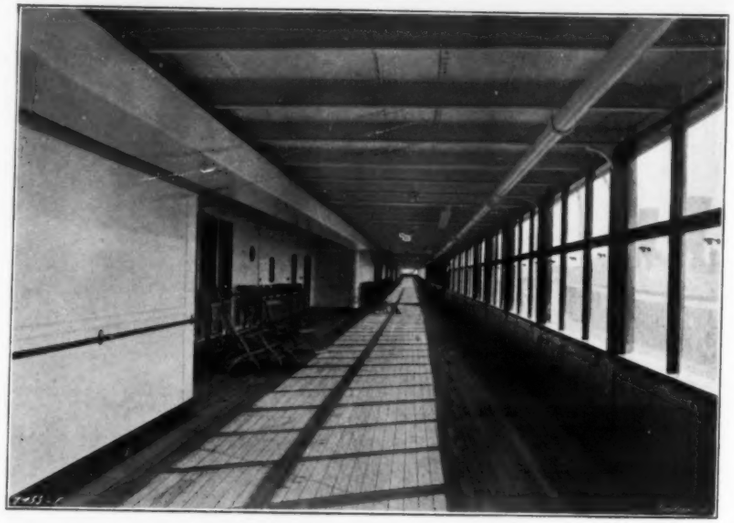


FIG. 19. ENCLOSED PROMENADE DECK.

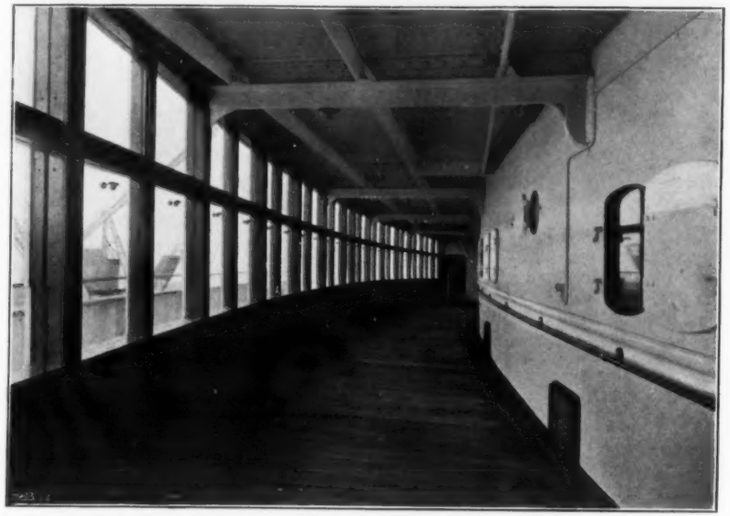


FIG. 20. THE OBSERVATION DECK.

FIG. 21. VESTIBULE AND ENTRANCE TO PALM COURT.

FIG. 22. SMOKING ROOM FOR FIRST-CLASS PASSENGERS.

(*To face Page 5.*)

ENGINEERING.

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Two Two-Page Plates and Four One-Page Plates.—*THE WHITE STAR QUADRUPLE-SCREW STEAMSHIP "MAJESTIC."*

ENGINEERING.

FRIDAY, JULY 7, 1922.

ELECTRICITY SUPPLY IN GREATER LONDON.

SPEAKING at the Commemoration Meetings of the Institution of Electrical Engineers in February, Dr. Ferranti said that at the time he was chief engineer of the Sir Coutts Lindsay Company, which supplied electric light in the west of London, he aimed at lighting the whole of London on the north side of the Thames, and with this in view extended the companies' mains as far as Chelsea and Hampstead. This would be about the year 1886, and one cannot but wish that Dr. Ferranti had been successful. The area of the Gas Light and Coke Company covers about 125 sq. miles and if the London Electric Supply Corporation had early achieved a somewhat similar field, one might have been saved something of the dreary story of electricity supply in modern London.

Since round about 1905 attempt after attempt has been made to unify the London supply systems in some way and the history of such attempts is a sorry tale of the dissipation of hard work and high hopes. The faith of the single-hearted is now placed on the Electricity (Supply) Act of 1919, but as far as London is concerned the voyage of that Act has so far "lain in shallows and in difficulties." At the end of last year there was a gleam of light in the dun sky when the Electricity Commissioners issued a statement on the inquiry into the formation of a Joint Authority for Greater London, which was held in June and July of last year. This statement suggested that a fair measure of concord had been reached between the various parties concerned and held out the hope that such an authority might be successfully constituted by agreement. The latest chapter in the long story dates from only a week or two ago when the Electricity Commissioners gave the County of London Electric Supply Company authority to proceed with the erection of the 100,000 kw. generating station at Barking for which they possessed powers subject to the Commissioners' consent. The manner of the reception of this proceeding by the Special Committee on London Electricity Supply of the London County Council suggests that one result of it may be fresh disagreement on the main scheme for a Joint Authority, and consequent further delay in the laborious attempts to introduce some unity into the electricity supply of London.

The permission to proceed with the Barking station which has been given to the County of London Company by the Electricity Commissioners is in no way unexpected, as in the report of December last already referred to, the Commissioners stated that they were "prepared forthwith to give their consent to its establishment." This naturally did not escape the attention of the London County Council Committee, and they have had some correspondence with the Commissioners in reference to it. The County Council position briefly is that this Barking station must of necessity form an important item in any future unification scheme, and that to allow of it being built at the present stage before the setting up of a Joint Electricity Authority is largely to predetermine the policy of the future authority. As the London County Council has purchase rights over the undertakings of the London electric supply companies it must necessarily play an important part in the formation of a Joint Authority. In the preliminary agreement the Council undertook to transfer those rights to the future authority, and in the event of the Council drawing back, it is fairly clear that the present scheme must fall to the ground.

It cannot definitely be suggested that the County Council are likely to make this matter of the Barking station one of new difficulty, and as the formation of a Joint Authority is subject to a further public inquiry the matter for the moment cannot profitably be discussed further. It is unfortunate, however, that the County Council Committee should have found it necessary to express disagreement from this decision. It would no doubt have been an advantage if the Joint Authority could have been set up before the Barking station was proceeded with, but in view of the history of electric power supply in London one cannot but fear that if this had been done the result would simply have been another of the disheartening delays with which the history of this subject is made up.

There is a perhaps overworked aphorism to the effect that a man who never makes a mistake never makes anything, and while we do not suggest that the Commissioners have made a mistake in this matter they have at any rate risked the possibility of a mistake. In this, they are fully justified. The Commissioners have at least done something positive. The electric power supply of London will obtain the assistance of a modern efficient 100,000 kw. station at Barking. The alternative to the giving of this permission was further postponement of some sort of modernisation in favour of still more of the discussion and argument on which this question has lived for the best part of twenty years. The building of the Barking station will be a definite move forward, and one hopes may help to force a general programme of some kind into being.

Although we approve of the Barking decision, that is not to say that no weight is to be given to the points in connection with it which have been raised by the County Council Committee. The importance of these points is overweighed, however, by the necessity of doing anything that will tend to end the present position of stalemate. The Council pointed out that although originally the Commissioners stated that they were prepared to approve the station for the purposes of supply in the County of London Company's own area, no such limitation has been imposed in the consent. The point, of course, is that if the output of the station is not really required in the County Company's own area then almost of necessity it will become a bulk supply station in any unification scheme. The Commissioners' reply to this is that the capacity of the station reasonably corresponds to the company's needs, and that it cannot be extended without their consent. A further Council point bearing on this matter is that the approved site of the station covers 91 acres, which it is suggested is considerably in excess of what is necessary for the Company's own needs. The reply to this was that the site was scheduled in the Act of 1921 on which the company were acting, and that the Commissioners had no authority to interfere with it in any way. The County Council also raised questions bearing on the calculation of the purchase price in the event of the station being taken over by a Joint Authority,

but we need not deal with the details of this matter at the moment.

As illustrating the complicated state of the whole London electric supply problem, and the urgent necessity for some kind of unification scheme and general agreement, reference may be made to the recent inquiry of the Electricity Commissioners into the applications of the South-Eastern Railway and the West Kent Electric Company for power to build generating stations on the Thames, at Charlton and Belvedere respectively. The outcome of this inquiry cannot be commented on as the Commissioners have not yet published an award, but the matter well illustrates the confused state of the whole question. The South-Eastern Railway desires the station for railway supply, but the West Kent Company is apparently relying on the same supply for an important part of the load on their proposed station. The South-Eastern Railway is, of course, to coalesce with the Brighton and South-Western Railways to form the Southern Group, and in the event of the Charlton generating station being sanctioned, it is reasonable to suppose that the Brighton load might in time be transferred to it. This load is at present supplied from a station which would fall to the Joint Authority if the present scheme for such an authority were carried through, so that those interested in the formation of such an authority have a direct interest in the proposed railway generating station. The proposed Charlton station would generate at 25 periods, which is the periodicity of the existing Greenwich station which is in the immediate neighbourhood, and as a consequence the London County Council and the supporters of a Joint Authority are concerned. Whether the Greenwich station is suitable for extension to carry the railway load need not now concern us, but clearly a public authority may rightly inquire if it is good public policy that such a further station should be built. A final matter we may mention is that the West Kent Company is closely allied with the South Metropolitan Company, and if in the event of the Belvedere station being built it transferred an important part of its load to that station, this again might affect the interests of a future Joint Authority.

THE SPECIAL MACHINE.

THERE has always been a wide divergence of opinion as to the relative advantages of special and universal machines. The problem has been brought about largely by the growing excellence and adaptability of the universal type of machine, which tends to limit the requirements for special machinery. Indeed, in purchasing a modern universal machine tool the customer practically obtains a whole series of special machines; for the machine is either adapted to perform many special jobs, or else accessories for the purpose can be bought from stock at a very reasonable figure. These facilities present themselves in a very favourable light when compared with the difficulty and trouble experienced in obtaining a really serviceable special machine of sound construction, and hence the use of universal type machines is widely prevalent.

Nevertheless comparatively few factories have any need of this type of machine. Repair shops, jobbing shops, and general engineering establishments are chiefly the works that require "universal" machinery, and in the term "universal" we include the ordinary "manufacturing" type of machine, for although it is not completely universal it has many adjustments and covers a wide range of sizes. Factories making any kind of speciality, even in a wide range of sizes, can manage 90 per cent. of their work on special machines; for the essential feature of a special machine is not that it will take only one component but that it will take only one class of work; thus despite the possibility of obtaining greater efficiency with special machinery there are several powerful considerations which weigh in favour of the universal type. The most important of these is the consideration of the possibility of a change in the product of the factory. Certainly, it seldom happens that the nature of the product is completely altered, but fairly large alterations are a common occurrence, and the prospect of a complete change is one which must, at least, be considered. In a change of this kind the owner of universal machinery would score heavily against the owner of "specials" as there would be comparatively little alteration required in the one case, but a large new expenditure in the other.

Another case, of more frequent occurrence, is that in which a factory, temporarily short of work in one or more departments, is offered a good batch of contract work for an outside firm. The contract work will probably be quite different from the ordinary line of business and here, again, the universal type of machine shows its value, for it can be changed over almost immediately, probably with cheap temporary jigs, and can thus earn a return where its special competitor would be idle. For this reason universal machinery can carry a far higher value in the assets of a company than special machinery could do, and it is, moreover, an asset in the true sense of the term. It has a two-fold superiority over the "special" in this connection, for, in the first place, it has a definite second-hand value where the "special" has probably only a scrap value and, in the second place, it assists in selling the factory as a whole because if the factory is equipped with general machinery it can be sold as a going concern to almost any company doing engineering business, whereas if special machinery were installed the factory could only be sold as a going concern to a very limited range of possible customers. These are weighty arguments, and it is small wonder that boards of directors show a good deal of timidity in departing from a safe custom and spending large sums in purchasing machinery which, for anybody else, has little more than a scrap value. There are, however, very important advantages to be derived from special machines which make their installation, in the majority of cases, a sound policy.

The advantage of the special machine may be described, generally, as lying in greater adaptability to the work to be done. This increased adaptability is, of course, obtained by correct design. However good a general machine may be for any particular job, it is fairly safe to say that a machine designed for that purpose alone will be definitely superior. There is, however, no need to do the job in the same way when special machinery is used so that the best possible combination of operations can be adopted. For instance, it is very frequently found to be possible to combine a number of operations into one by the employment of a special machine, thus saving a very large amount of time in handling. In addition to this the actual operations themselves can be performed better and more quickly.

One of the most marked advantages of special machines is their increased rigidity. This is not gained at the expense of increased size, for the reverse is the case, but by a better distribution of metal to resist the stresses to which it is subjected. Most universal machines suffer from some weakness of frame or parts which is necessary in order to give adaptability. This can frequently be avoided in special machinery. A striking example is to be found in the milling machine, the overhanging arm of which is exceedingly flexible when free and none too stiff when the front straps are on. Special machines taking the same size of work show no signs of chatter at much higher feeds than can be used with the "universals" owing to the absence of overhang. Where it is not convenient to do away with overhung parts entirely the length of overhang can usually be very much cut down.

In addition to greater stiffness of the machine itself the adoption of a special design enables more rigid tools to be used and more rigid holders. On any existing machine the tool post is limited to some extent, but on a special machine it may be made as massive as is desired. It can also be shaped so that overhang of the tool is practically reduced to nothing. The tools, too, can be made exceptionally large and strong where this is an advantage, and this fact, together with firmer holding and a stiffer machine, frequently makes possible a very heavy cut such as could not be approached on a machine of regular pattern. These considerations apply especially to broad forming cuts, and heavy roughing cuts on medium and small sized work, and to drilling of medium and large sized holes. Where the work is small the standard machine may be too clumsy and, in particular may not be capable of giving high enough speeds to give efficient results. Illustrating from the operation of drilling it is almost certain that to get efficient work from drills $\frac{1}{32}$ in. diameter and less, a special machine would have to be designed or the speed of revolution would be too low.

The special machine taking an exceptionally heavy cut has frequently a marked advantage over a standard machine as regards supply of power. It may happen that the power demanded from the standard machine occurs at an awkward speed as, for instance, with a lathe on "open belt." The special machine is not at this disadvantage and can be supplied with a liberal allowance of power at any speed. The power can, moreover, be supplied in just the way required for the job; if gearing is objectionable then the power can be supplied by a broad belt or other means. An insufficiency of power is very annoying in any machine and causes belt trouble and tool breakage. In the special machine this trouble can be entirely avoided.

An advantage of the special machine which has not always attracted the attention which it merits is its small size when compared with the standard machine. It is frequently surprising into how small a compass a machine can be compressed when its range of action is limited to operating on one component or on one or two components which are very similar. A reduction of floor space to one-quarter can be obtained in the majority of cases, and where several machines can be united on a common base a reduction to one-tenth or even one-sixteenth of the floor space taken by a corresponding group of standard machines is not uncommon. If cubical space is considered, the results are even more striking, so that where a saving of weight is a consideration, as on upper floors, the special machine may open up completely new possibilities.

The most obvious gain from a saving of space is that of rent and rates. These charges when added to lighting, heating, and a proportion of the depreciation of the building make the expense of every square foot of shop space a considerable one. If this "floor burden" were carefully assessed for each shop the saving effected by compact machinery would be more readily appreciated. In quite a large number of cases the building of extensions, costing many thousands of pounds to build and many hundreds of pounds annually to heat, light and otherwise maintain, could have been entirely avoided by ruthlessly selling standard machinery and replacing it by special machines occupying, say, one-quarter of the space. There are, however, additional important savings which are obtainable by virtue of the small size of special machines. One of the chief of these is better supervision, for it is evident that if machines are smaller the operatives are in closer touch with the foreman. If the supervision is already good enough, then with smaller machines an increased number of operators under the same foreman is possible.

The increasing of the number of operators under the foreman may possibly be accompanied by an even greater economy; that of giving a greater number of machines to each operator. If the machines lend themselves to this—that is to say if their essential nature does not demand an operator apiece—it is a great advantage of special machines that they are not subjected to any trade union regulations, and their smallness makes it almost certain that they will be more readily handled than a standard machine so that more machines can be worked. In addition to this the saving of motions brought about by operating distances being less has a favourable effect in reducing fatigue and increasing production. These advantages have been mentioned in connection with smallness, but they accrue equally from other features of special machines such as simplification of operation and convenience of design. A further advantage of small size, is that it gives increased portability, which is exceedingly useful at times of overhaul or repair, enabling the machines to be sent outside, if necessary, without undue expense.

In considering the cost of installing special machinery it must not be forgotten that a large sum will be saved on jigs. Cases are not infrequent, when dealing with machines which can be arranged on a common bench, where the complete special machine is not much bigger or more costly than the

jig and fixtures which would have to be attached to the standard machine. Thus in these favourable cases the cost of the special machines is practically nil regarded from the standpoint of extra expense. In almost any case the designing of the general action of the special machine will not cost more than that of the corresponding jig, so that one of the chief expenses of special machinery—design cost—must not be considered too unfavourably.

The general question of cost of special machines depends very largely on the resources of the particular factory with regard to the degree of finish required. Certainly where the utmost accuracy is required and the finish is to be faultless the cost of making will be high, for in this case, if the work is sent out only the best-equipped factories can undertake it, and their charge must take account of possible "wasters" in construction. There are, however, many simple machines which do not require the highest accuracy and finish, and these can usually be made at a competitive price. In either case the cost must be compared with the corresponding saving in jigs, the possibility of superior finish being produced and the saving in operation time effected. When this is done, it will usually be found that the special machine is an exceedingly profitable investment.

NOTES.

The Institution of Electrical Engineers' Conversazione.

In point of attendance the annual conversazione is the most successful of the various activities of the Institution of Electrical Engineers, and this year's function, which was held on the 29th ult., was no exception to the rule, some 1,700 guests attending. As usual the conversazione was held in the Natural History Museum, South Kensington, which is large enough to allow of adequate accommodation being arranged for the numbers attending. The guests were received by Mr. J. S. Highfield, the President, and Mrs. Highfield. The string band of the Royal Engineers performed in the Central Hall, and concerts were arranged elsewhere for those who required other entertainment than was afforded by the conversation, introductions and friendly meetings which are essential features of such gatherings. The President was able to welcome many distinguished guests, and the whole evening was in every way successful, and well reflected the present activity and progress of the Institution.

The Institution of Mechanical Engineers.

We regret that we omitted to include in our report published last week (page 807 *ante*) of the recent visit of members of the Institution of Mechanical Engineers to Liége, reference to a ceremony which took place on the occasion of the closing meeting at the building of the Liége Association of Engineers, when that body officially bade farewell to the President, Dr. H. S. Hele Shaw, and the Council of the English institution. This meeting afforded the President and Council of the Institution of Mechanical Engineers the opportunity of placing a wreath on the memorial of the Association to the Liége engineers who fell in the war. The wreath of flowers will be replaced by a wreath in wrought bronze which will be a permanent memento of the visit. Since his return from Liége the President of the Institution has received a letter from the President of the Liége Association of Engineers, in which the latter states that "the members of the Liége Association of Engineers have been profoundly moved by the touching thought shown by the Institution, in the homage paid to the memory of their comrades who fell in the defence of right and liberty. Your courteous act is to us a precious indication of the sentiments of esteem and friendship which you have shown to us, and will contribute in a large degree to intensify the cordial relations between us."

The Training of Apprentices.

Much ink has been spilt in discussing the question as to whether engineering aspirants should take their college course before or after entering the shops. On the one hand it is urged that if a youth enters the shops first, and then goes to college there is an important break in the continuity of his training, whilst if the other alternative be adopted, he goes into the shops at an age when soiling his hands in manual work has become more distasteful than at an earlier age, and the stricter discipline is also less readily accepted after the easier *régime* of the college. Messrs. J. I. Thornycroft and Co., Limited, in devising their interesting scheme for the training of pupils and apprentices have taken the view that practical and theoretical knowledge should be acquired simultaneously. In the old days, this plan was, of course, followed to a very large extent, and the more ambitious apprentices spent much of their scanty leisure in attending evening classes. For many the strain thus imposed was too severe, whilst in other cases the regularity of their studies was often seriously interfered with by the necessity of working overtime. Messrs. Thornycroft get over this difficulty by arranging for the classes to be held during the ordinary workshop hours, and the time thus spent is paid for just as if it had been spent in productive work in the shops. The classes are held in the works, and the works laboratories afford opportunity for the gaining of experience in the testing of materials. Pupils spend thus two and a-half days per week whilst the ordinary trade apprentices attend the classes for half a day per week, but those showing exceptional application or brilliancy are permitted to take the full course, and as stated, are paid just as if they were working at a machine or at the bench. The scheme of studies is so comprehensive and complete that Messrs. Thornycroft believe that in most cases their pupils would gain little or nothing by a subsequent course at a full time technical college, and that their system gives a pupil an engineering education second to none obtainable in this country. They point out, however, that much depends upon the student himself, and they reserve the right to cancel the privilege of attending the classes, in cases in which the progress made is unsatisfactory.

The Corrosion of Iron and Steel.

In presenting a paper on the "Corrosion of Iron and Steel" to the Royal Society last week, Sir Robert A. Hadfield, Bart., F.R.S., drew attention to an aspect of the iron-resources problem which is too little heeded. Professor J. W. Gregory recently estimated that, if the iron output should continue to grow at the pre-war rate of increase of 5 per cent. per annum, the world's supplies would be exhausted in 150 years. Last year the production of pig dropped from 78,000,000 tons to 33,000,000 tons; but this reduction was only temporary, Sir Robert considered, and if China should begin to use steel in the same quantity as the inhabitants of the United States, the output of pig would, according to Dr. J. S. Unger, of the Carnegie Steel Company, soon be doubled, and half-a-million tons of steel would be consumed every 24 hours. The awakening of China has been delayed; but it will come, and it is one of the great factors we should reckon with. Sir Robert estimated the total sum spent annually on counteracting the ravages of corrosion at well over £500,000,000. The Royal Society had only once discussed this problem before, viz., in 1917, in connection with a paper by Sir Robert and Dr. E. Newbery. In his present communication Sir Robert dealt with the much-contested question of the advantages of adding small proportions, 0·16 per cent. to 0·26 per cent., of copper to the steel. His varied experiments show that, as regards atmospheric corrosion, the resistance of such copper-steel is greater than that of ordinary mild steel, whether the rolling scale be left on the material or be removed, especially when the air contains an appreciable amount of sulphurous impurities. In sea water ordinary steel corrodes more rapidly at first than copper steel; subsequently, however, the corrosion of both the materials slows up. Tap water is not so corrosive initially as sea water, but becomes more corrosive, due to the absence of any self-protective action; but there is little to choose between the two materials. Sulphuric acid of 50 per cent. attacks both the materials rapidly at first when the scale is on; the corrosion rate is subsequently maintained for ordinary steel, whilst it becomes much slower for steel containing copper. A short test in sulphuric acid of 20 per cent. on specimens with the scale removed confirmed the superiority of the copper-steel. The manner in which so small an amount of copper, a quarter of 1 per cent., effects this improvement, is still little understood, but Sir Robert's experiments throw some further light upon this point. The paper was illustrated by numerous photomicrographs and specimens of fractures of non-rusting steels of various compositions, as well as those used for this recent research. Some of the specimens had been exposed in railway tunnels. There was an interesting discussion by Dr. Newton Friend and others.

THE INSTITUTION OF NAVAL ARCHITECTS.

On Tuesday, the 4th inst., members of the Institution of Naval Architects assembled at 10 a.m. in the Grand Amphitheatre of the Sorbonne, Paris, together with a number of their colleagues of the Association Technique Maritime. The meeting was opened by Mr. Bertin, the president of the association, at whose side sat the Duke of Northumberland, the president of the Institution, there being on the platform Mr. Landry, formerly Minister of Marine; Admiral de Bon, Vice-President of the Marine Superior Council; Admiral Fournier; Mr. Doyere, Director of Naval Construction; Admirals Besson and Le Bris; Mr. Lannes, of the French Transatlantic Company; Mr. Nizery, of the Chargeurs Réunis; Mr. Patry, of the Bureau Veritas, besides members of the Association Technique Maritime and a number of members of council of the Institution.

The proceedings were opened by Mr. Bertin, who extended a cordial welcome to the Institution on behalf of the association, a younger sister of the Institution, but a strong one. Speaking of naval construction generally, Mr. Bertin stated that it could rightly be considered the greatest triumph of modern genius and as the noblest profession. The Sorbonne, for the second time in its history, had the honour of receiving the Institution, the first occasion having been twenty-seven years ago.* But since the foundation of the Sorbonne, in the thirteenth century, it had counted among its students many of British nationality, evidence of whose stay in Paris was afforded to this day by such street names as Rue des Anglais and Rue des Ecossais in the district. He recalled the visit to Paris and to the College de France, in which the meetings of Wednesday and Thursday were to be held, of several well-known British scientists, whose object was to view the instruments of Regnault and of other French savants, adding that since those early days down to the present time, the relations between the two countries had become closer and had been strengthened by the *entente*.

The Duke of Northumberland said it was difficult for him to find words to express the gratitude of the Institution for the most hearty welcome they had received on the part of the French sister association. No invitation had been more appreciated by them than the invitation to visit Paris on the present occasion. The former meeting, which was held in Paris twenty-seven years ago, to which Mr. Bertin had referred, had had invaluable results, not only in promoting naval construction, but also, and this was most important, in bringing the two nations closer together. He expressed the hope that the present meeting would be equally fruitful in good results. Twenty-seven years ago, our two countries had comparatively little in common. Distrust had arisen, sometimes leading to a certain amount of clashing in various fields. There was then no common danger to be faced together, no enemy common to both, no memories of perils and hardships shared together, and no memories of a triumph achieved in common. Since that former meeting all had been changed. A danger common to both nations had led them to combine their naval and military policies, to face as one unit the barbarism of the great war. The guns had ceased their work of destruction, but the bonds uniting the two nations had not been dissolved; the two nations having suffered together could not forget what they owed one to the other. He illustrated his point by giving two reasons for this,

* See Engineering, vol. lix, pages 768, 789.

one being that about 1,000,000 of British troops were sleeping their last sleep on French soil, the second that both nations were still confronting at the present day the same danger. From the point of view of the relations between the two countries, the Duke of Northumberland added that Governments "had their day and ceased to be." What counted in the long run was not the statesmen, but the people; the people counted, and had no intention of being baulked. The unity of France and England was the corner stone on which rested the hopes for the future, and the present meeting was one confirmation of that unity. No institution had benefited more by collaboration with France than had the Institution of Naval Architects; great progress had been made in ship construction since the former Paris meeting, and much of this had been due to French ingenuity; the submarine, for example, had been greatly fostered in France. He thanked the members of the Paris University for having allowed the opening meeting to take place in the Hall of the Sorbonne, a courtesy which had entailed much inconvenience to themselves, and he thanked also the President of the Association Technique Maritime, Mr. Bertin, for his warm welcome. The cordial reception extended to the Institution afforded a most convincing proof that not only naval affairs, but also other matters which both countries had at heart, would be furthered by the present meetings.

Naval Design and the Washington Conference.

The first paper taken was one having the title "The Tendency of Naval Design as Affected by the War." It was by Sir Eustace T. d'Eyncourt, K.C.B., who read it to the meeting. We reproduce it on page 27. It was taken in conjunction with the second on the list for purposes of discussion, the second paper being one by Major L. Fea, of the Royal Italian Navy. This was entitled "Some of the Consequences of the Washington Conference with regard to Naval Construction." It was read in abstract by the Secretary, in the absence of the author. We reproduce this paper on page 28.

The discussion was opened by Admiral de Bon, who, in the first place, stated that he had been deputed by the Minister of Marine to welcome the Institution to Paris, and to express the Minister's great appreciation of the present and past work carried out by the Institution. He was proud of having been selected for that mission. He was, also, particularly glad of having the occasion, on behalf of the Navy, of paying homage to the work carried out by naval architects, thanks to whom the Navy had been able to accomplish the heavy tasks it had had to face afloat. Mr. Bertin had recalled the early days, days in which navigation was in sailing ships; in modern ships, the triumphs of naval construction were revealed more and more as time passed. The problem of shipbuilding had always been a complicated one; it was more complicated than ever since the Washington Conference. Eminent statesmen had expressed their belief in a durable peace, but it was quite allowable to have doubts on the point. He (the speaker) for his own part, feared that all men who reflected at all whilst they might ardently long for peace, could not help realising that ever since men have existed there have been disputes and fighting; they had not lived together in that calm state which was so often referred to at Washington. For sailors one fact came into prominence during the late war, and it was to the effect that had it not been for the Navy and the work accomplished by the Navy, the war would have been lost. To say the least, therefore, the duty of the Navy was not finished. A part of the work of the Washington Conference turned upon devising means for restricting—limiting—the navies of the world. Sailors, for their part, considered that naval architects should now, more than ever, work on the preparation of naval equipment of which they believed they might stand in need in the future. On the face of it, the conditions laid down at Washington appeared almost impossible of realisation. Both Sir Eustace and Major Fea had put before the meeting the difficulties which would surround the construction of future warships. These would have to meet not only enemies on the surface, but also underwater enemies and enemies in the air, and on the other hand, these warships had been "tied hand and foot in design," and had been limited to the greatest possible extent in every direction. Sailors, Admiral de Bon repeated, were absolutely convinced that sea action would occur in the future, and had confidence that the naval architects would give them the right units, for overcoming the difficulties created. Submarines and aerial craft were modern, but both would be developed.

Mr. Doyère, who followed, speaking as a naval architect was glad to some extent that the Washington Conference had brought out the difficulties which surrounded the work of a naval architect; and he said "brought out" because those difficulties had always existed. The difficulties following upon a limitation of displacement, among others, were not all new difficulties, and there was every hope that the new ones would be overcome also. Naval construction had always been a compromise between various conditions. Displacement had very frequently been limited for a number of different considerations. The fitting of ships with quadruple gun turrets had for its origin the solving of a problem similar to the one resulting from the Washington Conference. In the future, the 35,000 tons limit, recorded by Major Fea, would not prevent a solution, and it should be remembered, as the author pointed out, that this displacement did not include fuel and feed water, the fuel and feed water increasing the ship's permissible tonnage. Experiments were being continued, bearing upon the qualities of materials used in shipbuilding, upon the weight of machinery, and so forth, and these experiments might lead to considerable progress. Resistance of the water to the forward progress of ships also had to be considered, and scientists in every nation were experimenting with models in this connection; their work would also aid in solving the problem now before the world. It was not rash even now to believe that these tank experiments might result in a saving of 8 per cent. or 10 per cent. in a ship's resistance to propulsion; this would lead to a reduction in weight and would mean a gain on the ship's displacement. The question of under-water protection was a very interesting one; it had been raised years ago, by Mr. Bertin notably, who had devised various means for counteracting underwater attack. Decks would most probably have to be protected mainly against aerial bombs. He would like to know in what directions this would be carried out; the strengthening of the decks was one possible line, but had others been thought out apart from increasing the deck thickness? Was the aeroplane-carrying ship one likely to have a long life? He asked the question because at one time a torpedo-carrying ship was a type formerly built, but one which ultimately became useless, owing to the increase in the size of the torpedoes. The same thing might occur with aeroplane-carrying ships, owing to the development of the aircraft. There was also the question as to whether aircraft could always land safely on its parent ship—on a platform which pitched and rolled with the ship itself.

Sir John Biles said the two papers considered the question under two different points of view. The one by Sir Eustace told the meeting what was to be done but said little as to the way in which it was to be carried out; whilst the paper by Major Fea stated the difficulties, what had to be done to meet them and, in many ways, the manner of doing it. The two papers brought one back to the outlook at the times of early battleship designs, when fights were carried out on paper and not on sea. It would seem as though for the next few years fights would be carried out on paper on similar lines. The situation left a large amount of scope to naval architects and engineers. There was a great difference between working in peace and in war time; in war time there was unlimited spending, whereas in peace the spending was limited. The problem now was, during a time of limited spending, to prepare an adequate force for a future emergency. The battleships were now limited to 35,000 tons, carrying guns of 16 in. maximum; there were to be also ships of 10,000 tons armed with 10-in. guns. Were those ships to be of one type each, either of 35,000 tons or 10,000 tons, or of several? He suggested the more probable course would be the building of patterns rather than solving the problem as to which would be the best ship for the immediate future. He contended also that the staffs should not be reduced; the men should be retained to be in a position to build when the opportunity arose. Major Fea's improvements relating to the use of more perfect materials, the general use of welding instead of riveting, and the incorporation of the protective with the structural elements formed together a most essential summary; along the lines he, the author, had set out there was plenty of room for investigations in matters of detail and for the development of different designs. Gratitude was due to Sir Eustace for the development during war time of the work of the Naval Construction Corps.

Admiral Fournier dealt with ship lines for increased speed. The war had proved that speed was a most important condition. In merchant marines also it was of great importance. The chief factor was in the lines of the ship. He called attention to the conclusions he had arrived at following experiments at the Grenelle Tank, on models ranging from those of Dreadnoughts down to submarines. There was, he said, a certain "angle d'attaque," an angle at which the hull met the water, below which the ships might have high speeds but above which, by reason of the wave formed at stem and stern, the ship could not attain to a high speed. Between this particular angle, of 10 deg., and one of 5 deg., all the ships could be included; they all could be classified according to their "angle d'attaque."

Captain Clifton Brown found the two papers very interesting, adding that he, as did other naval officers, rather welcomed than otherwise a reduction in the big ship size. Warships had got to such a state, from the dimensions standpoint, that officers did not know what harbours to make. The draught was too great for many ports, or docks. A limit had now been laid down, and as Sir John Biles had said, the thing to be done was to experiment during the next few years. The steadiness of the gun platform was the first consideration to be given attention to. The "Queen Elizabeth" class was an admirable type from that point of view. There was not much use in giving a large amount of torpedo power to the modern big ship; these in the course of the late war did not use their torpedoes to any extent, and by doing away with them, there would result an economy in space and in weight.

Sir Eustace T. d'Eyncourt, in the course of his reply, stated that the points which had been raised would take hours, even days, in discussing. It was unfortunate that Major Fea was not present to take part in the discussion of his paper; he (the speaker) thanked him for having contributed this, and also Admiral de Bon and the other French officers present. At the Admiralty they had greatly appreciated an order which had been received from the French Marine for six or eight sloops; great pride had been taken in the execution of that order, and the best efforts had been given to carry out the order in the smallest possible time and with the best workmanship. These ships had received the names of stars, and as there were still a great many names of stars left, the Admiralty would be glad to continue the order giving the ships to be built the names that remained. One of Major Fea's propositions was to reduce the number of guns carried by increasing the rate of fire. Considering that one round for a 16-in. gun weighed approximately 1 ton, the magazines would require to have an increased space and the weight of the ammunition carried would be increased also, therefore the proposition was not all gain. He (the speaker) noted Major Fea's improvement in the form of more perfect materials. In regard to welding instead of riveting, this could hardly, perhaps, be considered as yet a practical proposition, inasmuch as he (Major Fea) added that grave doubts probably exist as regards special steels. He (the speaker) doubted whether welding, as against riveting, would lead to a great saving. In the matter of incorporating the protective elements with the structural ones, this method had been followed in British ships for many

long years. This principle, Major Fea had said, had had an important application in the recent German light cruisers, and so forth; this statement he, Sir Eustace, could not allow to pass, for the "principle" had been adopted in British ships many years ago, and the Germans had followed us. Major Fea mentioned the bulge adjoining the keel as proposed and experimented upon by General Ferrati in 1911; Sir Eustace quite agreed that this system was akin to ours; we had developed ours two or three years before the war and the experiments upon the Hood were carried out entirely upon our own lines. He was fully aware of the work done by Italy, and we communicated to Italy and our other allies the result of our own work in this respect. We could, at any rate, claim equal credit for the protection of our ships. Under-water protection was an old problem, and during the war a request was made for an improvement in this direction, and for doing away with the torpedo nettings; the bulge had entirely disposed of the nets and no trouble had arisen thereby. He did not think officers would ask any more for nets. Speaking generally, naval architects should welcome the rules set down at the Washington Conference, for all start level. The rules were comparable to yacht builders' rules, and building had to proceed according to these, aiming at the best results. All naval architects would agree that no designer had ever had a free hand; in his designing of a ship there was, and always had been, a limitation, of money, draught and other points. Reference had been made to improved ships' models to reduce resistance, to weight of machinery and other important matters. In the designing of warships, the speed affected all the items of a ship; speed was the most extravagant of the qualities that could be given a ship, as was shown by the development of battle-cruisers as against battleships. There was no question as to the necessity of a steady gun platform. The Admiralty had experimented with bilge keels, and found that rolling had been checked to a great extent by an increased area of these. In regard to the landing of aeroplanes on a ship's platform at sea in all weathers, this was a difficult problem; in this, as in other matters, we were always progressing. The pilot's steadiness of hand and eye came in for a good deal, and both French and British pilots were most capable men.

On the motion of the chairman, the authors received the thanks of the meeting for their contributions. Both papers, he added, dealt with most important problems, on the successful solution of which the very existence of our two countries depended.

The meeting stood adjourned to the following day.

(To be continued.)

LITERATURE.

Crystallography and Practical Crystal Measurement. By A. E. H. TUTTON, D.Sc., M.A., F.R.S. Second edition. In two volumes. Vol. I. *Form and Structure.* Vol. II. *Physical and Chemical.* London: Macmillan and Co., Limited. [Price 50*s.* net, each volume.]

BUT few books have appeared of late years that treat exclusively the practical side of crystallography. The appearance of Dr. Tutton's well-known volume in 1911, was a comprehensive, if not an exhaustive, treatise and left but little room for useful addition, and further, crystallography has entered into and reacted upon so many cognate sciences, that it is to the history of these that one turns to learn the advances that have been made either in the method of working or in the results attained. That the subject has widened at a rapid rate is shown by the two handsome volumes now necessary to replace the earlier edition of one volume. Not a little has been contributed by the physicist who has taught us much, and conjectured more, of the arrangement of atoms in crystals; metallurgy has contributed its own lesson by demonstrating how much the character and structure of metals depends upon crystalline arrangement; chemistry has shed new light on the relations between valency and the disposition of crystals, though there are still disputed points that need research; many problems of physical optics have been rewritten from the point of view of crystallography. One might run through the whole gamut of physical science, and it would be found that the study of crystals had opened new avenues for research, or thrown fresh illumination on obscure places.

In consequence of these many points of contact and varying aspects, it is difficult to give an accurate idea of the scheme followed in a work that is intended both to assist the student and to exhibit the present position of the science. At the outset the student is well catered for by the demonstration of the methods of measuring the various physical constants of crystals and of conducting experimental investigation generally. After a brief account of the nature of crystals, and a description of their principal characteristics, together with some eminently practical remarks on the preparation and selection of measurable crystals, the goniometer is introduced, an instrument that the author persuades himself is admirably calculated to put to flight the difficulties that beset the tyro. Without disputing his great authority, we would suggest that it might equally well suggest others, just as embarrassing. Dr. Tutton's real aim, however, is to contrast the advantages of substituting the practical work of measurement and the methodical arrangement of the fundamental principles underlying the symmetry of crystals, for the purely mathematical foundation of the subject—a form of presenting a fascinating science that he thinks is apt to discourage and repel the student. He congratulates himself that as early as the fourth chapter (there are 60 in all) he is in a position to illustrate his subject by the actual measurement of a crystal of potassium sulphate, and from direct measures to derive in their natural sequence all the salient fundamental facts of crystal morphology. After treating of the theory of axes, the law of rationality, and the stereographic projection, the measurements of the crystal already made are worked out in detail. To reach this point some elementary trigonometrical expressions have to be supplied, to which the author refers as the "few indispensable formulæ required." The author prides himself on reducing the mathematical formulæ to a minimum, and claims that the student armed only with a book of logarithms can perform all the calculations necessary with the aid of the information given in four pages. This may be true if the student is to be content with reaching this elementary stage, but if he is provided with so slender a mathematical equipment he will find himself heavily handicapped in the study of the many related inquiries to which crystallography lends itself. It would seem to be a better policy to encourage the student to acquire more command of mathematical analysis than to emphasise how much can be accomplished with so little assistance.

Many chapters, indeed the main part of the first of the four sections into which the treatise is divided, are devoted to the consideration of the seven systems into which the 32 classes are grouped. The plan followed is to give first a description of the symmetry of a system, and to make this the preface to the actual working out on the goniometer of the complete measurement of a selected specimen. Some of these measurements, as that of a crystal of copper sulphate, an example of triclinic symmetry, are the results of original investigation, and all of them reproduce actual instrumental work. The value of the collection of this mass of varied measures from the hand of a master of the craft can hardly be overrated. Moreover, the numerical accuracy in all these examples is of a very high order. The agreement between the observed and calculated angles may prove the despair of the amateur, if his goniometer circles are small and his manipulation indifferent. Lessons in accuracy, however, are not to be despised and the author is justified and should be supported in his attempt to give to students a higher aim than to be content with acquiring an intelligent conception of the manner in which the information is acquired. If an incentive to the acquisition of rigorous accuracy be needed, it is supplied in a later chapter in which Dr. Tutton points out that his discovery of the law of progression of the crystal properties in isomorphous series, was due to greater refinement of measurement and careful selection of crystals. The use of inadequate measuring instruments and the choice of unsuitable material prevented the recognition of the change in the axial ratios and interfacial angles of the sulphates of potassium, rubidium and cæsium corresponding to the "progressive change in the atomic weight or atomic number of the contained metal, when potassium is replaced by rubidium and the latter by cæsium." There is much evidence of the increase of accuracy in measurement and problems of great delicacy such as the determination of the effects of temperature on crystal distortion being now attempted with success. Further, opticians have been incited to supply more convenient instruments for measuring, notably the goniometer with two or three circles, making only one adjustment of the crystal necessary, a form that is specially adapted to Fedorov's method of crystallochemical analysis for the rapid investigation of unknown forms. The author gives a very full description of this method, and though he writes with some reserve, evidently regards the method and the theory on which it is based as a valuable assistance to crystal analysis. One would respectfully associate himself in the sympathy expressed by Dr. Tutton in the loss to science by the death of this master, one among the many victims of the Russian anarchial revolution.

The second part opens with an account of composite crystals and twinning, a chapter being introduced on planes of cleavage and gliding. This leads to the discussion of the movement of glacier ice, and in connection with the observed phenomena some account is given of the foam cell, and pulsation theories of Quincke and Sir G. Beilby, respectively, the object of whose introduction is not very clear. But if we have been led along some tempting by-path we are speedily brought back to the main topic by the description of Bravais' work in demonstrating the geometrical existence of the 14 separate space-lattices, and the explanation which they afford of the empirical law of rational indices, of the homogeneity of the crystal, and of the development of the seven generic systems of crystal symmetry.

There are few more fascinating tales in the history of science than that which exhibits the connection between the work of Bravais, the joint results of other workers on similar lines, and the conclusions drawn from X-ray analysis. Sohncke, Schönflies, Fedorov and Barlow by their combined but independent labours indicated 230 types of homogeneous structure, represented by point systems, which include 165 involving the property of enantiomorphic structure and 65 Sohnckian assemblages of points which do not. The irrefutable conclusion is drawn, that the space-lattice represents the arrangement of the molecules, while the point system represents the plan of distribution of the atoms. It is inviting to pursue the subject further through the original thought of Von Lane to the masterly development of Professors Sir W. H. and W. L. Bragg, and their brilliant associates, from whose work it may be shown that X-ray analysis has not only confirmed all the main conclusions held concerning crystal structure, but established them beyond the chance of refutation. It is a tale of absorbing interest that Dr. Tutton unfolds, and one which compels the attention of the reader. He can write proudly and justly "that not one single conclusion or principle presented in the first edition has been shown to be invalid or incorrect." It is a matter for sincere congratulation that theories built up on exact measurement and fearless deduction have been so convincingly supported by long-sustained investigation in another and independent field of inquiry.

It is almost of the nature of an anticlimax to turn to the third section, in which the optical properties of crystals are discussed. Many treatises on geometrical and physical optics have made the ground more familiar, but interest is still aroused by the abundance of detail and the method of its arrangement. An especial emphasis on crystal measurement is needed, however, for the investigation of optical characteristics is too often neglected, though the examination of the behaviour of light through a crystal is most desirable, as it can afford decisive guidance when the goniometric measurements leave any ambiguity. The instruments and methods for deriving the optical properties are fully described—given the necessary mechanical skill

one may succeed in the cutting and grinding of prisms and plates, erect his own apparatus, produce monochromatic light of any desired wave-length, and master the intricacies of the crystallographic microscope. The determination of the positions of the principal axes of the optical ellipsoid and the refractive index of the crystal by the various means indicated will give scope to the most ingenious, and the production and examination of interference figures will be a source of pleasure to all.

The fourth and last section is new matter, the subjects of which it treats being purposely excluded from the earlier edition from considerations of space, but now inserted with the view of making the work as complete as possible. The subject of isomorphism is one with which the author has particularly identified himself, and a chapter is devoted to it, although already referred to in an earlier section. As an introduction to the thermal properties of crystals considerable attention is directed to polymorphism, the term being limited to those conversions in the form of a crystal which are brought about by change of temperature alone, without either fusion, evaporation, or the intervention of a solvent, thus excluding any confusion with chemical isomers. The thermal properties of crystals and the interferometric determination of the thermal expansion are other subjects treated with fullness. Here a description of Langley's bolometer is given, and more appositely an account of the author's own interferometer, which is capable of general application for the measurement of very minute distances or small amounts of motion, and therefore a valuable accessory to the laboratory. In this section the author ventures to indulge in the convenience that mathematical formulæ offer, but with fear and trembling lest he might discourage those unfamiliar with the notation. This departure is necessary to explain some of Dr. Tutton's own work on thermal expansion. Space, too, is found for a chapter on pyro- and piezo-electricity and the magnetic properties of crystals. The book concludes with a chapter on "liquid crystals," a subject of which we heard much more some years ago than we do now, but it is proper that due acknowledgment should be made to Professor Lehmann.

It is, of course, impossible to mention, far less to do justice, to the wealth of information collected, or to indicate the ability with which the facts are arranged. We enjoy the privilege of sharing in the matured experience of one who has laboured long and fruitfully in this field. The diagrams and illustrations declare the hand of a master, who has practised and extended every step in the processes described.

Real Mathematics, intended mainly for Practical Engineers, as an Aid to the Study and Comprehension of Mathematics. By ERNEST G. BECK, Wh. Ex., Assoc. M.Inst.C.E. London: Henry Froude and Hodder and Stoughton. [Price 15*s.* net.]

FOR some time past engineers have been encouraged to believe that they should acquire their mathematical knowledge by other routes than those which have been approved by time and found sufficient and suitable for students, who use the same training for other objects. The genius and insistence of the late Professor Perry did much to foster this view, indicating the benefits likely to accrue by a departure from old methods, and many since, possessing neither his experience nor his insight, have sought to perpetuate or to enlarge his scheme, by the issue of a series of text books usually described as "Mathematics for Engineers." Some, perhaps many, of these are able and well-arranged treatises, but one may take the initial objection that such attempts represent the engineer as incapable of profiting by the long-established methods, and requiring to have his appetite pampered and spoon-fed in order that he may assimilate a few unpalatable mouthfuls, or they insinuate that the discipline of severe mathematical training is no longer desirable in the engineering profession. It is only necessary to recall the extensive use recently made of the methods of vectorial geometry in electrical engineering, and of the growing importance of hyperbolic functions, to show how unwise it would be for the engineer to neglect any branch of pure mathematics.

The present work which is a very good specimen of its class, apparently owes its origin to a general dissatisfaction with the methods generally adopted in explaining the elementary principles—rather than to any ambitious attempt to cut a royal road to the subtleties of mathematical analysis. In many works addressed to engineers, the object pursued seems to enable the student to provide a correct solution to a given problem, though he be hampered by very imperfect knowledge of the principles underlying the process. Here, the author so often lingers over a principle, that the student may possibly never reach his goal. There are some methods and processes, so simple, that any effort to explain them results in the introduction of greater difficulties than they were intended to remove. Simple addition will provide such an instance. When we began to read this author, we had no doubt but that $3 + 5 = 8$, but after reading a few pages in which the author elaborates this simple proposition, doubts were raised, or it would be more correct to say, that the spirit of contradiction incited ingenuity to devise some numerical subtlety, in which the author's reasoning might prove faulty. That is not a desirable attitude to encourage in a neophyte. Similarly, when advanced to multiplication, the assertion that it is impossible to multiply the most common thing of everyday life by 2, seems so opposed to the language of ordinary life, that it tempts a similar wasteful expenditure of misdirected energy. One of the objects of teaching is to introduce simplicity, but the author's attempts to explain conventions or to prove axioms suggest difficulties that would not have been anticipated. His use of illustration drawn mainly from accountancy practice is often apt and judicious, but an illustration is not a proof, and its value may be diminished and its appositeness disfigured by assuming the principle whose proof is sought. The author undertakes a difficult task in attempting to demonstrate the truth of the rule, that "the product of like signs is plus, and the product of unlike signs, negative," if the class be disinclined to accept pedagogic authority. But not content with disposing of this giant, he boldly attacks the further problem, that the square of a negative quantity is positive and the cube of a negative quantity negative, though here the author winces a little, and after much discussion of the formula $+ \{ (-x) \times (-x) \} = +x^2$, he recommends that the student be left to himself to work out on similar lines the arguments explaining $(-x)^5$. In the course of the argument, the author makes the assertion that obviously $\sqrt{-25}$ is -5. Will he assert that equally "obviously," the root of $\sqrt{-1}$ is -1. Lest the author should think the remark too flippant, we would like to say that we consider some of his geometrical illustrations in the same chapter admirable and appropriate, explaining very satisfactorily the cause and amount of the error produced in some of the abbreviated methods that have been proposed for extracting square and cube roots. Generally, wherever geometrical construction, as in the introductory section or differentiation and integration, can be usefully employed, the author enlists its aid in the cause of enlightenment. No doubt many profit by such assistance, but as Mr. Beck himself readily admits, "a mathematical demonstration which may be quite satisfactory to one, may prove totally unsuitable to another." For instance, a student may read his proof, that the three angles of a plane triangle are together equal to two right angles, say that he cannot understand it. But without doubt it will prove a source of illumination to others, and this difference of appreciation is the justification of all such books. On the other hand we find the chapters on equations and their graphs easily comprehensible and think the processes admirably adapted and adequately explained, but fall away again when faced with the familiar quadratic. This simply means that the manner in which the subject is presented is unfamiliar, but those who approach the subject for the first time, unhampered by previous knowledge or conventions, may find the method simple and the introduction of the Halma board, a delightful addition to the usual schoolroom equipment. To these, many of the devices used, such as that of assets and liabilities to explain the meaning of + and −, may offer peculiar advantages, but the method of illustration can be carried to excess and prove a hindrance. In the treatment of logarithms of fractions, for instance, involving negative characteristics, the method of keeping a petty cash account with "Balances in hand" and "Advances drawn," is cumbersome. The trouble comes from not permitting the cashier to borrow more than sufficient to just pay his way. In the case of logarithms of trigonometrical functions to which the author makes no reference, the cashier faced with a succession of deficits boldly borrows and pays in tens, instead of units, and the operation is greatly simplified. The consequence of the preservation of this dual system of dealing with the characteristics of fractions is, that in certain cases requiring the multiplication by $\frac{1}{2}$, the computer has to deal with the inconvenient quantity of $\bar{1}.69897$, but if the sine of 30 deg. be involved in the formula, he uses 9·69897 without compunction or inconvenience. Let those who have to use any complicated formula say which is the easier in practice.

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Practical Refrigeration for Marine Engineers. By H. E. ROBERTS. Glasgow: James Munro and Co., Limited. [Price 4*s.* 6d. net.]

A Practical Treatise on the Metals used in Marine Engineering. By W. H. COLPITTS. Glasgow: James Munro and Co., Limited. [Price 10*s.* 6d. net.]

Coal-Tar Colours in the Decorative Industries. By A. CLARKE, F.C.S. London: Constable and Co., Limited. [Price 6*s.* net].

Textiles. By A. F. BARKER, M.Sc. *With Chapters on the Mercerised and Artificial Fibres and the Dyeing of Textile Materials.* By W. M. GARDNER, M.Sc., F.I.C. *Silk Throwing and Spinning.* By R. SNOW. *The Cotton Industry.* By W. H. COOK, M.I.Mech.E. *The Linen Industry.* By F. BRADBURY. Revised edition. London: Constable and Co., Limited. [Price 15*s.* net.]

Industrial Motor Control. Direct Current. By A. T. DOVER, M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6d. net.]

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THE UNITED STATES STEEL INDUSTRY.—It is reported that in unfilled orders, the United States Steel Corporation's total at the end of May was 5,254,228 tons, this being the largest total of any month since May, 1921, when unfinished business totalled 5,482,487 tons.

INDUSTRIAL NOTES.

THE Labour Party Conference, to which we referred last week, ended its sittings at Edinburgh on Friday. Nothing of a very notable character eventuated, part of the Thursday session being devoted to an attack, which failed, on Privy Councillors, while on Friday a demand was made by a small section that interest on War Loan should be reduced. This resulted in a good deal of disorder, but the matter was dropped. A resolution demanding greater provision for scholarships from legacies and bequests for educational purposes was adopted, the idea being apparently that the Government should step in and direct money left from the purpose intended by the testator, and apply it to provide greater facilities for the education of poor children.

At the Industrial Court, Westminster, before which the question of a reduction in wages in the printing trade has been argued, Sir William Mackenzie stated on Tuesday that the Court had come to the decision that a case had been made out for a reduction. Proposals were then made as to amounts and dates of operation, and it was stated the Court's decision would be announced in the course of a few days.

The Annual Conference of the National Union of Railwaymen commenced unofficially, as is now the custom, with a mass meeting on the Sunday preceding the opening day. At Bradford, on Sunday last, Mr. J. H. Thomas and Mr. C. T. Cramp addressed a large meeting, which recorded its satisfaction with the reports issued by the general secretaries. On Monday the conference was opened officially, and the president for the year, Mr. J. Marchbank, of Glasgow, delivered an address, in which he referred to "the attack upon the standard of living which the employers had driven so relentlessly home." We regret that anyone in such a position as Mr. Marchbank should use language which implies that the standard of living can be considered independently of other economic factors. The endeavour to maintain war inflated scales of wages has been one of the chief factors in rendering products too expensive for the private purchaser; hence the reduction in trade, hence unemployment (with relief until the national purse exhausts itself). In point of fact, the insistence on uneconomic scales is one of the surest ways of ultimately bringing about a much greater reduction in the real standard of living than are wage reductions sufficient to assist in securing orders, and encourage trade revival. It is, of course, recognised that methods of manufacture and business organisation should also be improved where possible to secure a reduction of costs, and that wages might be left till these others had been proved to be insufficient. It is unfortunately a fact that in many cases the unions themselves have interfered to prevent the introduction of better methods, and so have practically rendered necessary a reduction in pay instead.

On Tuesday the Congress considered the question of unemployment, which was said to be one of the inherent evils of the capitalist system, and the direct result of the Treaty of Versailles. Mr. J. H. Thomas, in his remarks, said that even the substitution of a Labour Government for the present one would not automatically cure all the evils, as some people seemed to imagine. With regard to the idea that the abolition of capitalism would cure unemployment, Mr. Thomas pointed out that as we have to import our food for at least four days of the week, and pay for that by exports, without capital we should be worse off than we are to-day.

A protest was made against the Trades Union Act Amendment Bill, now under consideration in Committee. On Wednesday the extremists managed to get a debate on two resolutions, one asking Mr. Thomas to resign from the Privy Council, and the other from the post of General Secretary, but were defeated.

The situation in the coal industry has been the subject of a good many meetings and discussions during the week. A special meeting of the National Executive of the Miners' Federation was called for yesterday (Thursday), when a proposal was to be brought forward to give notice to the owners to terminate the present agreement. Mr. W. Straker, of the Northumberland Miners' Association, stated recently that there could be no real improvement in the industry until the world's trade was restored. Mr. F. Hodges, speaking at Dalkeith, said there was not sufficient income in the industry, and the employers had overdrafts at the banks. The Government, he said, alone had the power to rescue the miners and their families, and should meet the difference between wages and the cost of living out of the taxpayers' pocket. It may be added that the Labour Party Conference at Edinburgh adopted the usual resolution demanding the nationalisation of the land, mines, railways, &c., which would involve the same thing, but which has been clearly decided against by the people of the country in no indefinite way.

Mr. F. Gibson, Secretary of the South Wales Coalowners' Association, states that the rate the industry can afford to pay for July is still less than the minimum, and that the owners, in order to pay the minimum, will have to pay £26,000 out of their standard profits. Since November last the owners had had to pay over 1½ millions sterling in order to make wages up to the standard minimum.

The questions of non-unionism and alleged victimisation, referred to in this column last week in connection with South Wales, have been brought before the Joint Disputes Committee. The appointment of a sub-committee on these subjects has been agreed to.

A joint conference was begun on Wednesday in London, between representatives of the National Employers' Federation and the Amalgamated Engineering Union and Kindred Societies with regard to the abolition of the war bonus. The case for a reduction was stated by Sir Allan Smith. Mr. J. T. Brownlie and Mr. J. Hill replied. At the time of going to press no conclusion had been reached.

The unemployment returns for the week ending June 26 show that on the registers of the Unemployment Exchanges there were then 1,404,900 persons wholly unemployed. This is a decrease of about 30,000 on the previous week, and 418,833 less than the corresponding week of last year. The number on short time was 105,900, compared with 102,958 in the previous week.

A letter addressed on Friday last to the Press Association by the Secretary of the River Thames Dry Dock Proprietors and Ship Repairers' Association, points out that while the question of the use of the Poplar bowling-green by the unemployed is being discussed, there is little doubt that many of these unemployed have for some time been refusing legitimate employment. At the present time there is a dispute in the ship repairing-trade. An offer for a settlement was made in excess of the terms accepted nationally some weeks ago, but with no result. Vessels are being diverted to the continent and other ports. The dispute affects 19 repairing firms in Poplar alone.

The annual report of the Ship Constructors and Shipwrights' Association shows a reduction of about 2,000 members from the number of 47,414 on the roll last year. The total income during the year was £137,728, while the total payments made amounted to £232,048. At the end of 1921 the reserve fund stood at £174,672. On trades and dispute benefits the sum of £2,496 was expended, and on unemployment the sum of £116,928.

It will be remembered that some time ago two cases were brought to light in connection with the carpenters and joiners' unions, of pressure being brought upon certain members to discontinue participation in the co-partnership scheme of Messrs. Lever Brothers, Ltd. It was held that participation in any such scheme prevented the men from acting loyally by their union, and that as the rules provided that any member working against the interests of the union might be fined or expelled, the society was justified in refusing to allow these men to continue as members. The men refused to give up the co-partnership scheme, and brought an action, claiming an injunction against the unions from expelling them. This was dismissed by Mr. Justice Eve on the ground that the Court had no jurisdiction in the case. On being taken to the Court of Appeal it was held that there was jurisdiction. This was appealed against by the unions, and the case was further argued on Friday last in the House of Lords. On Monday it was announced that judgment on the appeal was reserved.

The unfortunate position of the Lord Roberts Memorial Workshops was brought out before the Select Committee on the Government Training of ex-Service Men at the House of Commons on Monday last, when Colonel D. S. Kennedy stated that some of the trades unions had refused to handle material made at these workshops, and the result had been a tragedy. The remark alluded to a contract with the Office of Works amounting to between £3,000 and £4,000. They could take more men at any of their factories, subject to receiving the full Government grant.

In the United States the railway shopmen of six shop craft unions have been called out on strike by their presidents in an attempt to resist wages reductions authorised by the Railway Labour Board. The railway shop labour question is at present very complicated in the United States. Some time ago, on account of the high scales of wages which they were forced to pay, the railroads arranged for their rolling stock repairs to be done by contract firms. In some cases the work was done in the contractors' shops, but in others in the railroad's shops, leased, we understand, to contractors. It has been ruled, however, that such contracting is not permissible. Again, the situation has been complicated by the fact that it has been ruled that railways are not allowed to negotiate directly with their men, but must accept the rulings as regards pay, classification, etc., of the Labour Board. This decision has been disputed. The latest development is that the Labour Board has declared illegal the unions which have struck, and has ordered that new organisations be formed to represent the shopmen. An effort was made to bring the maintenance-of-way men into the strike but has failed. The coal dispute continues, but a warning of Government intervention has been given unless it is terminated shortly.

Germany is at the present time very unsettled. A strike in newspaper printing works is said to have extended to the whole trade, including managers. A rush on the banks resulted from a belief that the bank officials were contemplating striking, while a half-day general strike was called for Tuesday, to enable demonstrations to be held on the question of "the protection of the Republic." In addition, a strike of engineers has crippled all shipping, including tugs, at Hamburg and Cuxhaven. And the mark stands at about 2,000.

PUBLIC WORKS AT PRETORIA.—H.M. Senior Trade Commissioner in South Africa has forwarded to the Department of Overseas Trade a copy of an article recently appearing in the Johannesburg press regarding the proposals of the municipal authorities of Pretoria concerning the raising of a loan for the carrying out of improvements and extensions of public facilities at Pretoria. The proposed improvements include, *inter alia*, the erection of a new electric power station, tramway and sewage systems, fire stations and public halls.

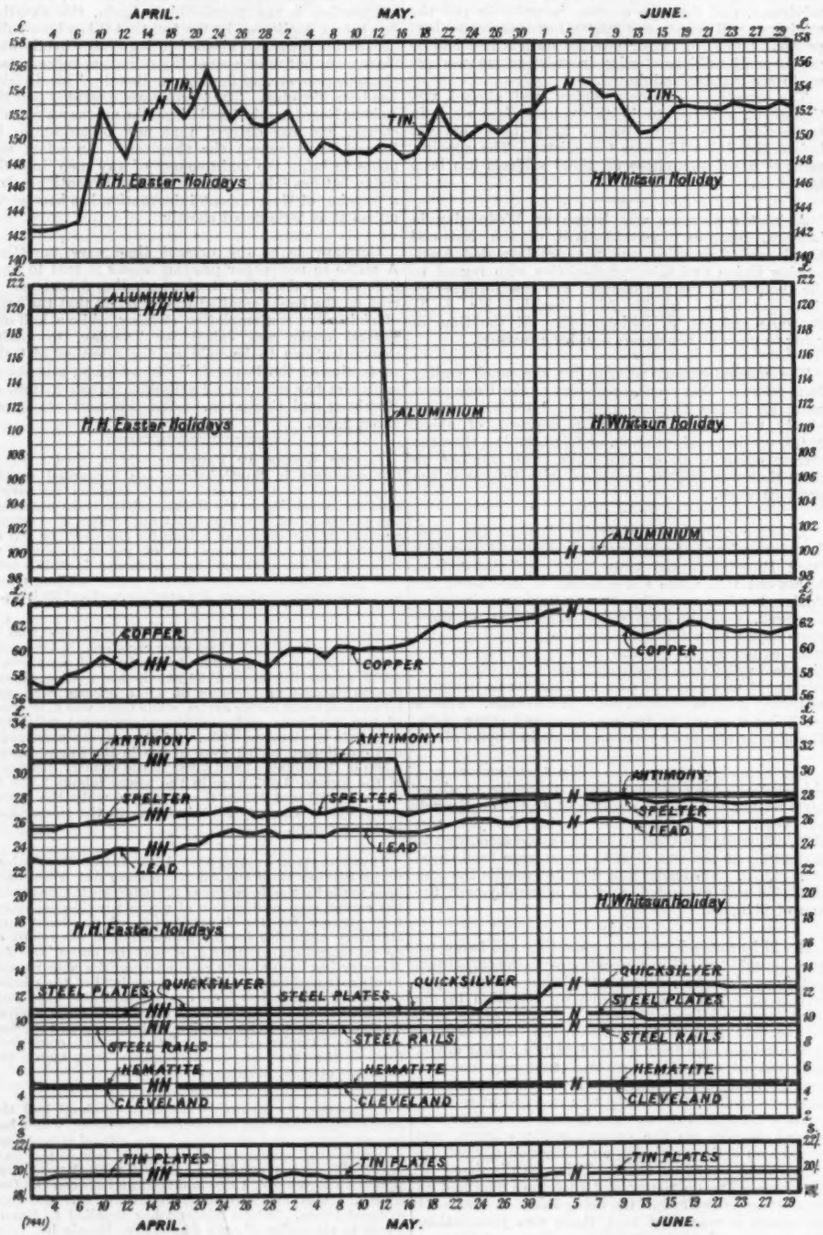
MOTOR TRAFFIC IN DENMARK.—It is estimated that in the latter part of 1921 there were registered in Denmark 15,635 private cars, 1,946 taxi-cabs and omnibuses, 4,679 motor lorries and 14,241 motor cycles. These figures showed an increase of 4,041 private cars, 892 lorries and 2,059 motor cycles, while there was a decrease of 330 taxi-cabs and omnibuses compared with the figures in September, 1920. Of the private cars, taxis and omnibuses, 10,701 were in use in the towns (about 4,500 in Copenhagen) and 6,880 in the country districts; of the lorries, 3,697 were in the towns (about 2,350 in Copenhagen) and 982 in the country; while the use of motor cycles was only slightly larger in the towns than in the country.

INVESTIGATION OF AIRCRAFT ACCIDENTS.—Regulations under Section 12 of the Air Navigation Act, 1920, have been made by the Secretary of State for Air to provide for the compulsory notification of aircraft accidents, statutory powers for the investigation of accidents, and statutory authority for the publication of the report of an investigation. Hitherto, it may be noted, the Air Ministry has been able to conduct enquiries with respect to aircraft accidents only by the goodwill of the parties concerned, but it has been deemed desirable that such enquiries should be placed upon a statutory basis, such as those carried out in connection with marine and railway accidents. Copies of the regulations, which come into force on the 12th inst., can be obtained from any of the branches of H.M. Stationery Office.

CONDITIONS IN FINLAND IN 1921.—Finland had the good fortune to escape the socialist experiment which has ruined Russia, and according to an official report just issued by the Department of Overseas Trade, is now in a fairly prosperous condition. Peace with Russia was signed on October 4, 1920, and trading between the two countries was resumed in April, 1921, but on very unequal terms. Whilst Finland has supplied to Russia goods to the value of over £4,000,000, Russia has been able to supply practically no products in return. Labour troubles in 1921 have been few, and such strikes as have occurred have been non-political. Foreigners, however, seem far from welcome, being subject to special taxes. On the transfer of shares, or on succeeding to real property they are required to pay double duties, and in the case of a transfer of shares from a Finnish citizen to a foreigner, the latter is required to pay a special duty of 10 per cent. of the nominal value. In addition, the foreigner is subject to special income taxes, both communal and state. The wood pulp industry is one of the most important, and much finished paper was also exported, 58,000 tons being sent to Great Britain alone. The timber trade was controlled by a combine during 1920, and fixed prices at a limit in excess of what it was possible to secure, so that it ultimately broke down. The price per standard for 7-in. battens was £28 to £30 in 1920, but fell to £10 per standard in October, 1921, which was not far from the pre-war rate. Business has, however, been greatly hampered by fluctuations in the Exchange. The cost of living is said to be more than eleven times as high as in 1914. But little British shipping enters Finnish ports. Thus in the navigation season of 1921, out of a total of 862 steamers entering Helsingfors, only six were British. The improvements being made at this port are nearing completion, and it is expected that the deep-sea harbour will be available for use this year.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent £1. each, except in the case of the diagram relating to tin-plates, where they represent 1s. each.

PERSONAL.—British Insulated and Helsby Cables, Limited, beg to intimate that, as from July 1, they are removing their London office from Lennox House to Surrey House, Embankment, W.C. 2.

ROYAL AERONAUTICAL SOCIETY.—At a council meeting held on June 28, Professor Leonard Bairstow, C.B.E., F.R.S., Fellow, was elected chairman of the Royal Aeronautical Society for the year 1922–23, in succession to Lieutenant Colonel M. O'Gorman, C.B., Fellow, whose period of office terminates on September 30 next.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon, July 3, Sir James Crichton-Browne, treasurer and vice-president, in the chair; Viscountess D'Arcy, Miss E. Fairfax, Sir Thomas Fisher, K.B.E., Mrs. Grove-Hills, Mr. J. Hetherington, Mr. A. J. Lambert, Mr. W. F. Roch, Captain Riall Sankey, C.B., Lieutenant-Colonel J. A. Stirling, D.S.O., M.C., and Mr. C. Tierney were elected members. The death of the Prince of Monaco, an honorary member of the Institution, was announced, and a resolution of condolence was passed.

AIR PREHEATERS FOR BOILER FURNACES.

THE greatest source of loss in connection with steam boiler operation is the quantity of heat carried away to waste by the flue gases. The days have long passed in which a high exit temperature of the gases was tolerated for the sake of producing natural draught and economisers are fitted in all plants of any importance in order to utilise as far as possible the heat which the boiler itself cannot extract from the gases. The close regulation of the excess air supply to the fires which is rendered possible by the use of CO_2 recorders has had its natural effect in increasing the temperature of the exit gases, and this again has called attention to the amount of recoverable heat which these gases contain. In addition to extracting a part of this heat by means of economisers, or indeed as an alternative to the use of economisers, it has often been proposed to use the heat of the waste gases to raise the temperature of the air supplied to the fires. The practical benefits of doing this are claimed to be greater than one would deduce from simple arithmetical calculations. The advantage does not stop with the mere return of so many heat units per hour to the furnace. The hotter air supply naturally increases the furnace temperature, and consequently increases the rate of radiant heat transmission to the boiler in a much greater ratio, and it is stated that this increased rate of heat transmission has the effect of reducing the flue gases leaving the boiler to a temperature actually lower than they would have had had the furnace been supplied with colder air.

There are two ways by which it has generally been attempted to raise the temperature of air for combustion. In steel works furnaces a common practice is to pass the fresh air and the flue gases alternately through regenerating chambers, so that the incoming air picks up heat from the brickwork previously raised to a high temperature from the passage of the flue gases. For boiler furnaces the flue gas temperature is not sufficiently high to make this plan practicable, quite apart from the difficulty of carrying it out. Hence when regeneration has been applied to steam boiler plants it has been customary to transmit the heat from the waste gases to the incoming air, through metallic surfaces separating the air passages from the flues. Heat transmission under such circumstances is not very effective, as the temperature difference is not great and the surfaces of the heating device are liable to become covered with a very badly conducting layer of soot or tarry matter.

The air preheater which we illustrate on pages 25 and 26 has been devised by Mr. Frederick Ljungström, of Stockholm, whose originality and fertility of mind have been demonstrated in the design of the Ljungström steam turbine and turbo-locomotive. It embodies neither of the principles referred to above, but carries heat continuously in a mechanical way from the flue gases to the incoming air. Fig. 1, on page 25, shows the external appearance of a Ljungström air preheater for boiler work, and Fig. 2 illustrates diagrammatically the internal arrangements.

Referring to the latter figure, fresh air is drawn by a fan into the upper portion of the casing, which is divided into two parts by a vertical partition. The air is confined to one side of the partition, and passes downwards to a similar semicircular chamber, through the body of a porous cylindrical drum. The flue gases from the boiler traverse the apparatus in the reverse way, entering a lower semicircular chamber and passing upwards through the drum to the upper chamber, whence they are exhausted and impelled to the stack by another fan. The porous drum is kept in a state of continual slow rotation, so that the part heated by the flue gases is constantly passing to the other side of the apparatus and gives up its heat to the cold air sweeping through it. Similarly, of course, the cooled part of the drum is continually returning to be reheated by the flue gases. It will be observed that there is no transference of heat through metal, in the process. A deposit of soot or tarry matter does not therefore have any very serious effect upon the action of the apparatus, which moreover may be cleaned in a few moments by means of a steam jet. The latter blows the soot along with the air going to the furnace, so that what heat value it has is returned to the fire.

The porous drum is illustrated separately in Fig. 3. It is built of thin sheet steel, and divided into sectors by radial plates, which serve as stiffening spokes. Each sector is packed with a number of thin sheet steel plates, which are kept apart by a large number of small channel-shaped strips spot-welded to their sides. The appearance of a group of these plates, with channels attached is shown in Fig. 4, while Fig. 5 shows the top of the drum in position, the cover-plates having been removed for the purposes of the photograph. The attachment of the channel strips is done on a special, but very simple spot-welding machine, a series of cams on a shaft making the welds one after another as the

AIR PREHEATER FOR BOILER FURNACES.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

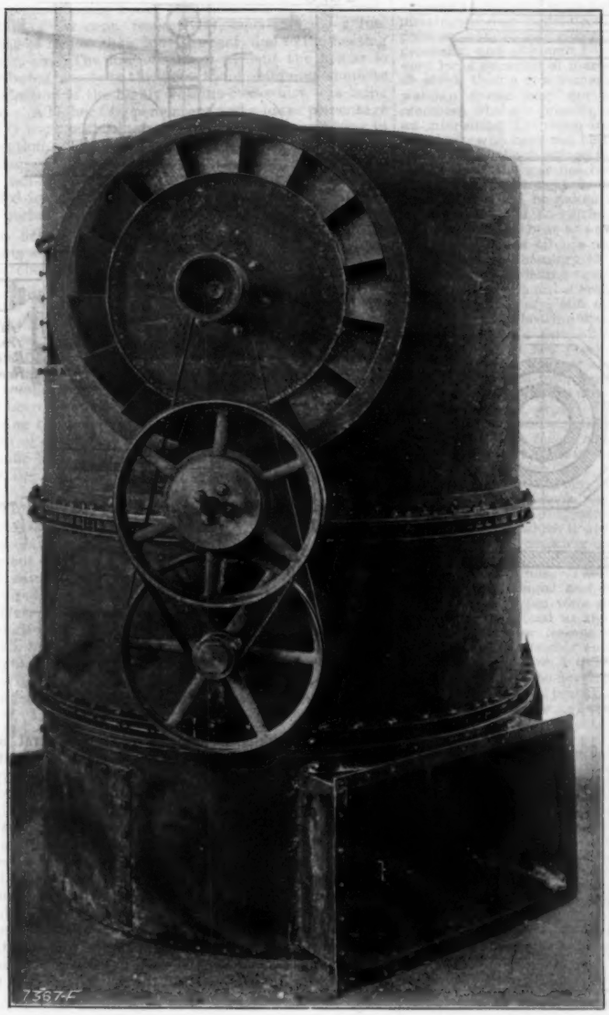


FIG. 1. GENERAL VIEW OF AIR PREHEATER.

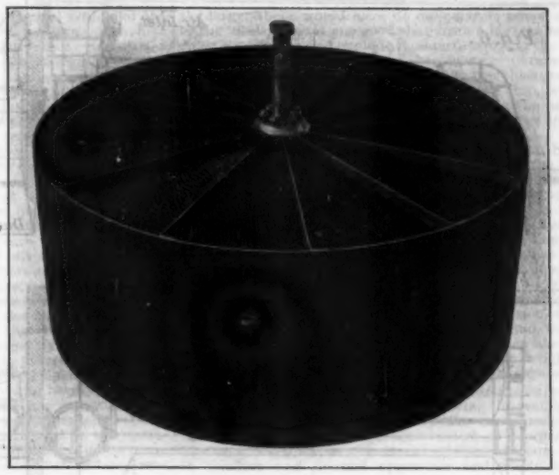


FIG. 3. ROTOR REMOVED FROM HEATER.

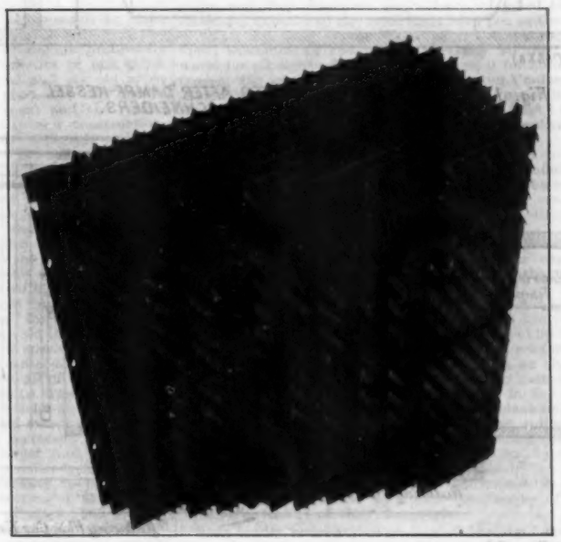
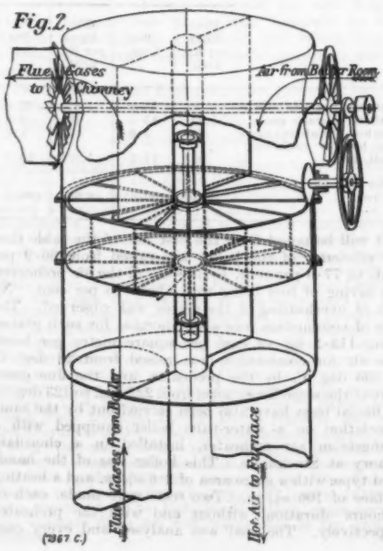


FIG. 4. PLATES WITH WHICH ROTOR IS FILLED.



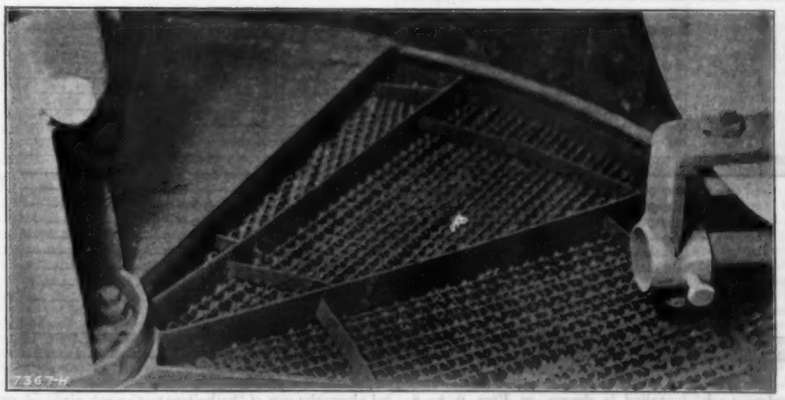


FIG. 5. VIEW OF TOP OF ROTOR IN POSITION.

plate passes beneath the contact points. The whole construction of the rotor is such that it offers very little obstruction to the passage of gas and air through it, yet brings the gas and air into intimate contact with a very large metallic surface.

The actual arrangement of one of the first Ljungström

AIR PREHEATER FOR BOILER FURNACES.

CONSTRUCTED BY THE AKTIEBOLAGET LJUNGSTRÖMS ANGTURBIN, ENGINEERS, STOCKHOLM.

Fig. 6.

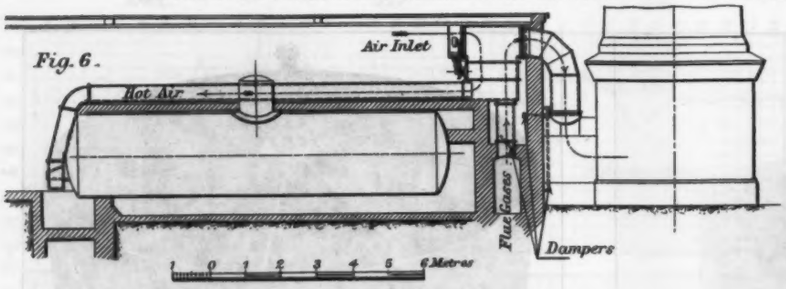


Fig. 7.

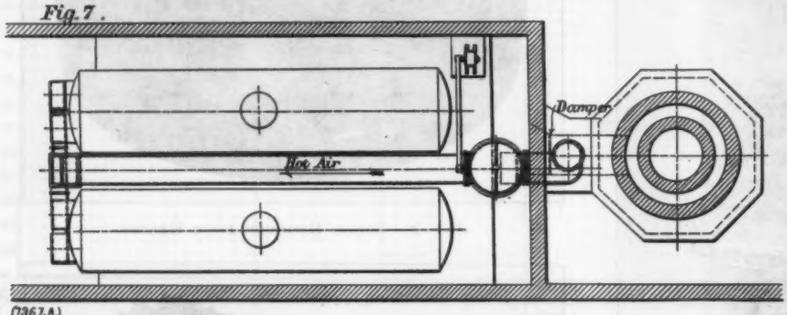


Fig. 8.

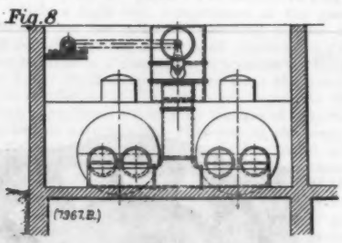


Fig. 9. AIR PREHEATER.

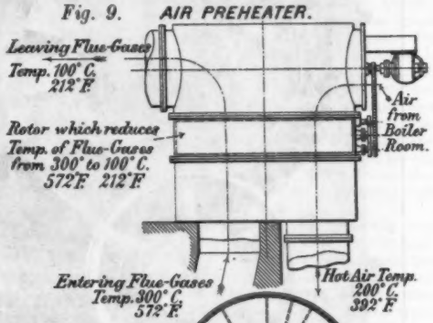


Fig. 10.

Fig. 11. ECONOMIZER, CALCULATED AFTER "DAMPF-KESSEL" BY R. SPALKHAVER AND FR. SCHNEIDERS.

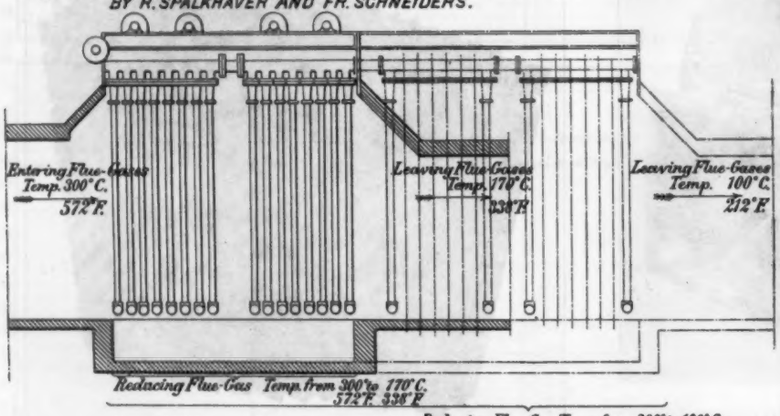
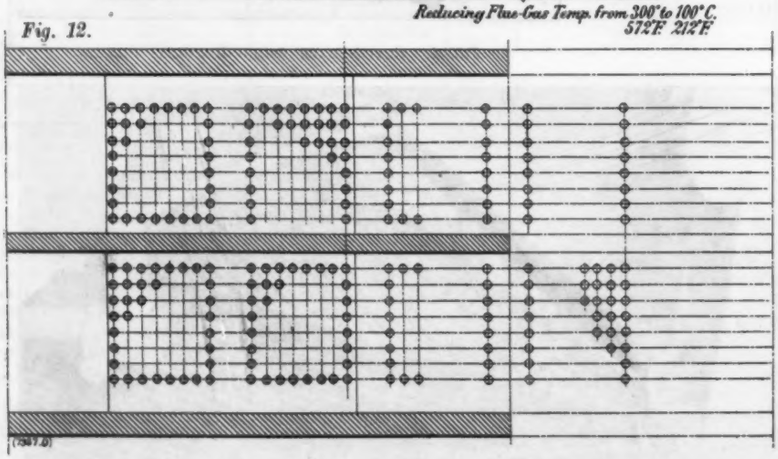


Fig. 12.



preheaters to be installed is shown in Figs. 6 to 8, on this page. It was put to work in conjunction with a pair of small hand-fired boilers already existing and in service. The preheater was mounted over the flue at the rear end of the boilers, and the flue gases returned to the flue outside the wall. The hot air was led along the top of the boilers to the ash pits. A small motor of about ½ h.p. carried on a bracket from the boiler-house wall drove the fans and the rotor of the preheater. Comparative tests on a boiler at Messrs. Ljungström's works at Gashaga, Stockholm, with and without the preheater in operation, were carried out by independent engineers of the Central and Northern Swedish Steam Boiler Association about a year ago. The boiler was of the return tubular type, with a heating surface of 66·3 sq. m., and fitted with an ordinary grate of 0·6 sq. m. area for hand firing. The conditions of the test were somewhat unfavourable to the preheater, as the grate area of the boiler was so small in relation to the heating surface that the waste gases normally left the boiler at an unusually low temperature. Moreover, the upper part of the boiler and the steam dome were unlagged, so that the whole efficiency was lowered by excessive radiation losses. All measurements were made in a careful and scientific manner, and the coal and the waste gases were analysed. The following table is given in the official report of the Steam Boiler Association :—

	Test I, without Preheater.		Test II, with Preheater.	
	Heat Units per Kg. Coal.	Per Cent.	Heat Units per Kg. Coal.	Per Cent.
Heat transferred to steam	4,509	66·9	5,370	77·6
Heat lost in waste gases ..	1,031	15·3	401	5·8
Heat lost by unburnt gases	243	3·6	125	1·8
Heat lost by radiation, ash, &c...	957	14·2	1,024	14·8
Net calorific value of coal	6,740	100·0	6,920	100·0

It will be noted from the first line of the table that the efficiency of the boiler was raised from 66·9 per cent. to 77·6 per cent. by the use of the air preheater, the saving of fuel being thus about 16 per cent. No sign of overheating of the grates was observed. The rate of combustion was about normal for such grates, being 113·2 kg. of coal per square metre per hour. The air for combustion was raised from 29 deg. C. to 135 deg. C. by the preheater, and the flue gases were at the same time cooled from 222 deg. to 123 deg. C.

Official tests have also been carried out by the same association on a water-tube boiler equipped with a Ljungström air preheater, installed in a chocolate factory at Stockholm. This boiler was of the hand-fired type, with a grate area of 2·6 sq. m. and a heating surface of 106 sq. m. Two tests were made, each of 6 hours' duration, without and with the preheater respectively. The coal was analysed and every care

taken to obtain reliable measurements. Without the preheater 12,584 kg. of feed water were evaporated by 2,100 kg. of coal, having a net heat value of 6,940 calories per kilogramme. With the preheater 13,068 kg. of water were evaporated by 1,724 kg. of coal having a net heating value of 7,020 calories per kilogram. The corresponding boiler efficiencies are 59·3 per cent. and 74·3 per cent. respectively, thus showing a fuel saving of no less than 20·1 per cent. due to the heating of the air. The low efficiency without the heater is attributed largely to the difficulty of obtaining complete combustion of the highly volatile coal which was being used. A higher CO_2 percentage and a lower percentage of CO were both obtained when the air heater was in operation. The latter raised the air temperature from 40 deg. to 238 deg. C., the temperature of delivery into the ash pit being 228 deg. C. The flue gases were cooled from 322 deg. to 168 deg. C. in passing through the preheater.

In neither of the installations of which the test results are given above, was there an economiser fitted. It is claimed that as an alternative to an economiser the Ljungström air preheater is not only more efficient, but is smaller and lighter and cheaper both in first cost and maintenance. Figs. 9 and 10, on page 26, show an air preheater designed to deal with the flue gases from a steam plant burning 1 ton of coal per hour, and Figs. 11 and 12 drawn to the same scale, represent an economiser for the same duty. In both cases it has been assumed that the temperature of the flue gas leaving the boiler is 300 deg. C., and that every kilogram of coal burnt gives 18·6 kg. of flue gases, with a specific heat of 0·24. In cooling these gases down to 100 deg. C., the heat liberated is 248 calories per second. It has been found by experiment that each square metre of surface in the rotating element of the Ljungström preheater will absorb 0·7 calories with the temperature difference which is obtained when the element rotates at a speed of 6 r.p.m. Thus to absorb 248 calories per second, a surface of 355 sq. m. is required, and as the flue gases act on only half the total surface, an aggregate surface of 710 sq. m. must be provided in the rotor. With the standard design, 1 cub. m. of the rotor has a surface of 385 sq. m. and a weight of 875 kg. The required volume of the rotor is therefore 1·84 cub. m. This would be obtained by making the rotor 0·4 m. (1 ft. 4 in.) high and 2·4 m. (7 ft. 11 in.) diameter; the resulting weight being 1,620 kg. (3,570 lb.).

An economiser designed to absorb the same amount of heat from the flue gases would require 512 tubes, each having 1 sq. m. of heating surface. Each tube would be 9 ft. long, and they would weigh on the aggregate 40,000 kg., or 88,000 lb. The length of the economiser would be 6·8 m. (22 ft. 4 in.) and the width 2 m. by 1·6 m. (10 ft. 6 in.). An economiser of this size is shown by the full and fine lines in Figs. 11 and 12. It would not however, be commercially practicable to instal an economiser to deal with the same heat-drop as the air preheater, and normally an economiser would not reduce the flue gases to a temperature lower than about 170 deg. Such an economiser would be as shown by full lines in Figs. 11 and 12, and to reduce the temperature to 100 deg. C. the tubes shown in broken lines would have to be added.

For marine boilers, the Ljungström air heating system is particularly well adapted on account of the great amount of regeneration which can be effected by an apparatus of very moderate size and weight. Various arrangements have been designed to suit different conditions on shipboard, and before long it is hoped that actual results of their operations will be available.

The makers of the Ljungström air preheater are the Aktiebolaget Ljungströms Angturbin, Arsenals-Gatan 2, Stockholm.

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100 YEARS OF ENGINEERING.—Messrs. C. B. Wardman and Co., Limited, 122, Great Portland-street, W.1., sole concessionaires for the Ruston-Hornsby cars, have just issued a pamphlet bearing the title "100 Years of Engineering." The pamphlet is devoted mainly to the modern product in the form of the Ruston Hornsby car, of the firm of Messrs. Ruston and Hornsby, Limited, which firm, as is well known, had its origin in the two firms of Hornsbys of Grantham and Ruston Proctor of Lincoln. The 100 years take us back to the early days of the Grantham concern, actually started in a smithy by Richard Hornsby in 1815. The firm has many notable points in its history. Its development of the Hornsby-Akroyd oil engine is well known. In 1905 it won a Government prize of £1,000 for a military oil tractor, with a bonus of £180 for exceeding the requirements. This machine was subsequently fitted with chain track invented by Mr. David Roberts, and was the forerunner of the system applied to such good purpose during the war. When the caterpillar tractor first interested Grantham it was little thought how valuable the idea would ultimately prove to us. The firm of Ruston and Proctor dates back to 1857, and in 1918 the two combined. The high ideals which characterised the separate firms are well maintained in the present business.

THE TENDENCY OF WARSHIP DESIGN AS AFFECTED BY THE WAR.*

By Sir EUSTACE T. D'EYNCOURT, K.C.B., D.Sc., F.R.S., Vice-President, Director of Naval Construction.

THIS summer meeting, taking place, as it is, in Paris, appears to demand more than is usually the case at the meetings of this Institution, some general *résumé* of the present conditions governing the designs of ships generally, and although I do not propose to go into the very large question of mercantile ship design, I venture to think that a few remarks on the present aspect of warship design may not be without interest to the members who are present, and may possibly call forth an interesting discussion from some of our Continental members, who have not had very frequent opportunities of attending the meetings in London.

Now that the war has been over for three and a-half years, we can glance at the whole situation with a calmer view than could be taken of it at a date less distant from the close of hostilities, when our minds were still working at fever heat to produce continuously improved weapons, both of offence and defence.

It is hardly necessary to point out that in the years immediately preceding the war enormous developments had been made in naval architecture, in marine engineering and in gunnery, and other branches of engineering science directly bearing upon the design and production of war material; but, although this development was very evident in the years immediately preceding the war, as soon as the war started it proceeded at an incredibly increased rate, being largely helped by the fact that during the war the question of cost hardly had to be considered at all, provided that the war material could be so improved and supplied as to aid in the achievement of victory. This factor alone contributed to the extraordinary advance made in every kind of scientific weapon, to a degree which has, I think, never before been approached; for, though in earlier wars the same kind of thing no doubt took place, on all previous occasions science had not progressed to anything approaching the condition in which it was found in 1914, and therefore on no previous occasion had it been possible to make such extraordinary improvements in scientific implements of all kinds. These improvements profoundly affected the designs and characteristics of our ships. Entirely new types were developed and the old types were improved, and as the war proceeded and battles were fought, new lessons were learnt and the results were as far as possible embodied in new construction. An interesting point, I think, is that although, as I say, new types had to be developed, yet it was found that all the existing types, perhaps with certain modifications, were of great utility, whether capital ships—battleships and battle cruisers—light cruisers, destroyers or submarines. Owing, however, to the long time which it takes to construct the heavier classes of ships, the developments made in the smaller types were more marked than in the larger, because the new material was always wanted at the earliest possible moment.

Now that the war is over and we have been able to think more calmly about the whole question of design, certain points stand out which call for more particular study and comment than was the case in pre-war days.

One of the principal points to be specially considered is the great development of under-water attack, whether by submarines, mines or torpedoes, all of which greatly added to the danger to which ships were continually exposed. Submarines became much more efficient, mines were laid in numbers over an extent never before dreamed of, and torpedoes were increased in size and efficiency, and were carried in larger numbers by all classes of ships, than had ever been previously experienced. It therefore became almost a necessity to pay special attention to the under-water protection of, at any rate, all the more important classes of ships, and it may therefore now be taken, I think, as an axiom that capital ships must have a very large proportion of weight devoted to their under-water defences. In this connection, I think it should be remembered that the older classes of ships, which had been designed some time before the under-water attack had become so imminent a danger, in almost all cases came off badly when struck by torpedoes or mines. This was due in part to the inferior protection given to the sides of the ships below water, and also very largely to the fact that in many cases longitudinal centre line bulkheads were fitted which prevented the ships retaining an upright position when damaged on one side; the large amount of water admitted was thus confined to the damaged side only, and in this way many of the older battleships and cruisers capsized. One of the first objects, therefore, was to improve this state of things, and none of our later ships fitted with the newer forms of under-water protection was ever lost by the action of an enemy torpedo.

The second great point of difference which has to be considered in post-war designs is the very much greater range at which actions were fought during the war than had been anticipated, and this in spite of the rather unfavourable atmospheric conditions which generally obtained in the North Sea. In future ships, therefore, the ever-increasing range of the guns themselves and of the distances at which actions are likely to be fought must be kept in view to an extent not contemplated in earlier designs. Before the war it was thought that actions would be fought at perhaps something under 10,000 yards' range. Now provision has to be made for ranges fully twice as great. To the ordinary observer it might not appear that this difference would very profoundly affect the designs of our ships, but a very little consideration shows what an important matter it is. At ranges under 10,000 yards the projectiles as a rule when striking the object are coming down at an angle of certainly not more than 15 deg. to the horizontal, whereas at the greater ranges the angle of descent of the projectiles may be 30 deg., or even more. At these steeper angles of descent the decks of the ships present a larger target than the sides, and with the old thicknesses which were given to protective decks in former designs, the larger shells would have no difficulty in penetrating to the vitals, so that one good shot from a big gun might enter a magazine and explode it, thus destroying the ship in a moment. It therefore becomes a paramount necessity to increase as far as possible the thickness of protective decks over the vital parts of the ship, whilst we still have to maintain the armour belt in the neighbourhood of the water-line in order to preserve intact the water-plane and the stability.

A further point necessitating special attention being paid to the protection especially of decks is the new menace of attack from the air. This has added an entirely new factor to modern naval warfare, though even at the end of the war this method of attack had not really been developed nearly as highly as it is likely to be in the future.

The naval designer, therefore, at the present moment is faced with the necessity for providing against new forms of attack both above and below water, all of which demand greatly increased weight in the working out of the design. At the same time he is offered no compensating advantage, or very little, in the reduction of side armour or any other item; for as the size and weight of the guns have continually increased, so has also the demand for higher speed, and therefore the weight of propelling machinery, boilers, fuel, &c., has increased.

Some advance has no doubt been made in the improved quality of steel, but any slight saving in weight of structure which can be made by the introduction of better material is not at present enough to compensate for the increase of weight due to additional items such as wireless and control apparatus and many other additional fittings.

These considerations, therefore, taken together, have tended to produce very large and very costly capital ships, and they would no doubt have increased to an enormous extent had not some limit been put to the size of ships and guns by the Washington Conference. In view, therefore, of the general necessity all over the world for economy of financial resources, if for no other reason, the enactments of the Washington Conference should be welcomed at any rate by the taxpayer if not by the men of the fighting forces themselves, and I may perhaps add, by the naval architects and suppliers of munitions of war.

Consideration of these points naturally leads to the questions: Are these enormous ships worth building? Can they be regarded as necessities? Can they be relied upon as the best means of defence and attack, or will they become an easy prey to some of the new methods of attack which have been enumerated?

Although the increased efficiency of attack under water, and also from the air, demands our earnest attention, nevertheless experience shows that the exaggerated claims of the enthusiasts who favour submarines on the one hand, or those who advocate aircraft on the other, should not be allowed to carry too much weight. For novel weapons it is always claimed by their advocates that at last an arm has been discovered which supersedes all others, and may, in fact, put an end to war, so irresistible is its power compared to that of all previous war material. Such claims have in the past been advanced for the rifle, the big gun, the machine gun, the torpedo, the torpedo boat, the submarine, and many other engines of war, but every time experience shows that the potency of new inventions can be met by some antidote, which largely discounts the value of the idea, and experience compels the claimants of irresistible force to modify their earlier optimistic prophecies of the wonderful results of their discoveries.

It is hardly necessary to go into all the arguments of the necessity for having capital ships; but after weighing all the facts it is generally admitted by competent authorities, that as long as ships of any kind sail on the surface of the seas, the most powerful surface craft will always be the principal unit of any Fleet.

As far as defence goes, at the moment our experiments and actual trials on the full scale show that we can make our ships reasonably secure against under-water attack from mines or torpedoes or from bombs dropped in the water alongside. Further, I consider that the decks can be so thickened as to be able to withstand modern gunfire at long range, or any bombs of weights which can at present be carried, provided always that too great demands are not made upon the naval architect to carry an abnormal weight of artillery or that the ships should at the same time be capable of very high speeds.

One thing is quite certain, viz., that with the enormous cost of capital ships, no wise man, whether he be a naval officer or statesman, would advocate the construction of the most expensive type of ship in these days of necessity for economy, unless he were convinced of the need for having them, and no experience of the war, or experiments since the war, show that it is possible to do away with capital ships, and to devote all the money available to the construction of cruisers, submarines, destroyers and other types. All these types are no doubt necessary adjuncts, but the most powerful capital ship it is possible to construct still remains the prime necessity of any first-class navy.

As regards other classes of vessels, the war showed the necessity, as I have said, of nearly all the classes previously developed, which was, I venture to think, in itself a testimony to the foresight and intelligence of the naval officers and naval architects of the various great Navies of the world. Demands were made in every class of ship for more speed, more armament, and more protection so that every type tended to get larger

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* Paper read at the Paris summer meetings of the Institution of Naval Architects, July 4, 1922.

and larger. This is seen in the continually steady increase in size of light cruisers, of destroyers and of submarines. Perhaps the development of the latter of these classes was the most remarkable of all and showed a greater percentage of increase of size and of speed in the same period than had been achieved in any other type of vessel. It is only a few years since the largest submarine was a few hundred tons' displacement. At the end of the war there were submarines of 3,000 tons weight and having speeds up to 24 knots; and the British Navy had developed some experimental boats carrying a 12-in. gun.

An entirely new type of ship, which was developed during the war, was the aircraft carrier. At first small merchant ships were taken up and adapted for this purpose, but as the necessity for carrying aeroplanes at sea became more and more insistent, larger vessels were taken up and the special arrangements for flying on and off were developed to a very high degree. Although most of the aircraft carriers are still converted ships built originally for other purposes, the alterations are so extensive that the ships as converted practically amount in many cases to an entirely new design. These vessels, which really correspond to the large hangars on land at the back of the fighting armies, are required to keep up with our fleets and therefore to have a high speed, to have good sea-going qualities, and to be steady platforms for flying off and flying on, with all the special fittings and arrangements necessary to carry out these operations successfully; and there is very little doubt that large aircraft carriers will in the future form an integral and absolutely necessary portion of any first-class Fleet, and further, these vessels will no doubt be specially designed for the purpose and developed to even a greater extent than has hitherto been the case.

It would seem to be difficult to arrive at any finality in the design of aircraft carriers, owing to the immense progressive development of aeroplanes, especially those of the larger classes designed to carry heavy bombs and other weapons of attack. To arrange for the safe flying off, landing, and stowage of these big machines, has given the naval architect new problems in ship design, which appear to call for quite as much inventive genius as any of the older problems with which naval architects have hitherto been faced.

Reviewing the whole situation generally of the tendency of warship designs as affected by the war, it appears that the naval architect has to deal with an even more complicated set of requirements which must be met in the up-to-date warship, than ever was the case before; for, in spite of the fact that the war lasted over four years, no finality was reached in the development of any of the weapons of war which were in use up to the Armistice, so that, although the ship designer is aware of the many varied and difficult problems which presented themselves to him during the war, most of which he successfully overcame, he has still to consider the further problems of more or less unknown character which the enormous development of science has brought about in the ever-increasing power of weapons of offence and defence which have to be provided for in the design of warships.

WASHINGTON CONFERENCE INFLUENCE ON WARSHIP DESIGN.

*Some of the Consequences of the Washington Conference with regard to Naval Construction.**

By Major L. FEA, Royal Italian Navy, Associate.

THE naval pact of Washington (January, 1922) has imposed severe restrictions upon certain types of battleships; they increase still further the natural difficulties which present themselves in the construction of a modern warship unit, and, as a matter of fact, the present requirements of a Super-Dreadnought are so serious in themselves that it is doubtful whether it will be possible to find a satisfactory solution of the problem whilst remaining within the limitations of the naval pact. I propose briefly to examine the rules set down by the Conference with regard to large battleships, having regard to the present state of technical knowledge and probable progress, and give a short survey of the question, with a view to initiating a useful discussion of this important problem. It is not my intention to discuss the actual value of large battleships, for it is obvious that as long as the naval gun of large calibre retains its present importance, the large battleship will remain the backbone of the Navy, and even though other weapons may develop it will remain, on the analogy that different arms of war generally complete one another, but are difficult to substitute for each other, in the same manner as the bayonet still remains even after the introduction of tanks and machine guns.

I would be glad if all those who have to judge this question would remember the words of Lord Lee of Fareham, with regard to the American experiments on aerial bombardment. "The same results could have been obtained, with considerably less expense and greater safety, with any of the ordinary methods of attack." I would also like to record here the conclusions drawn from a brilliant and complete study of this question made by Colonel Guidoni, naval engineer, a well-known constructor of aeroplanes, who in reply to the question "Battleships or aeroplanes?" replied, "Large ships and aeroplanes."†

The Washington Conference has decided, with regard to large battleships, the following limitations: (1) The "standard" displacement‡ of each ship must not exceed 35,000 tons; (2) the maximum calibre of the guns must not exceed 16 in.; (3) ships shall not be replaced under twenty years; (4) the "standard" total tonnage of battleships of the various Powers shall be as follows—Great Britain and America 525,000 tons each, Japan 315,000 tons, France and Italy 175,000 tons each.

Incidentally it may be said that the last clause will greatly increase the difficulties of the smaller navies, for it is more difficult to follow up progress and construct a homogeneous fleet, if it is only possible to build a ship every four years, than if one is allowed to build two or three at the same time.

The details of battleships built and in course of construction after the Battle of Jutland, tend to show that the "standard" displacement of 35,000 tons has already been largely surpassed; the "Hoods," the "Massachusetts," the "Tosa," all exceed 40,000 tons displacement, although the American and Japanese ships have the moderate speed of 23 knots. This proves that to-day it is impossible to unite all the requirements of a modern ship under 40,000 tons; on the contrary, as has been indicated by Sir G. Thurston, one requires to have 55,000 tons, if the locks of the Panama Canal were sufficiently wide.

The limit of 55,000 tons would not seem exaggerated if we consider that two 16-in. 45-calibre guns weigh, with their turret, more than 1,500 tons, that is to say, as much as the total armament of a battleship (pre-Dreadnought)—that the average weight of propelling machinery of 50,000 h.p. is more than 2,000 tons—that the armour alone of a modern ship weighs as much as the "standard" displacement of a pre-Dreadnought. In order to illustrate these facts, I give the weights of three ships, Hood, the most recent representative of the epoch of Jutland; Vittorio Emmanuele, designed by Cuniberti, one of the precursors of the modern high-speed battleship; Regina Margherita, by Micheli, predecessor of the ships of the King Edward VII type, the most successful type of the pre-Dreadnought period. These facts will be useful for further deductions, but it must be noted that they are not comparable, not only because of the diversity of type of ship to which they refer, but above all because the weights considered under the headings "Hull" and "Protection" are not quite the same.*

	Hood.		Vittorio Emmanuele.		Regina Margherita.	
	tons	per cent.	tons	per cent.	tons	per cent.
1. Hull ..	14,900	37·2	4,890	41·5	6,045	47·0
2. Protection ..	13,800	34·5	2,675	22·6	2,910	22·6
3. Armament ..	5,150	12·9	1,975	16·6	1,630	12·6
4. Engines	5,350	13·4	1,840	15·5	1,630	12·6
5. *Personnel* ..	800	2·0	450	3·8	670	5·2
Total.. ..	40,000	100·0	11,830	100·0	12,885	100·0

This table shows that during the twenty years which have elapsed between the building of the Regina Margherita and of the Hood, naval constructors have succeeded in preserving, practically unaltered, the percentages of armamant and machinery, so that with the absolute increase of displacement there has been a corresponding increase of displacement available for other purposes.

But this shows also that for this reason the 35,000 tons of the Conference are not sufficient, as stated above, if the problem of the present-day battleship is to be solved "without compromises." Is it possible to make better provision in view of possible progress of technical knowledge, or on the basis of acceptable modifications in the actual requirements of modern battleships? In order to arrive at a conclusion we will briefly examine the various requirements of the modern battleship, indicating some possible modifications.

Offensive Power.—The fundamental quality of a battleship is to possess the maximum possible offensive power, although this principle may tend to exaggeration as in the case of the Lepanto of 1880, and of the British ships of the "Furious" type, built in the recent war. This principle signifies the ability to do the utmost damage to the enemy in a certain space of time, by penetrating and destroying his protection by a great quantity of hits near or in the hull, and by poisonous gas inside his living quarters. It is therefore necessary that the ship, in a certain space of time, should be capable of firing a certain number of shots of sufficient power and accuracy.

After the Washington Conference it evidently will not be possible to adopt guns of less than 16-in. calibre. Whatever may be the definite results of investigating the effect of long-range shots with heavy projectiles and of attacking ships with poison gas, it is not impossible, especially in Southern seas, that new means of fire-control and spotting may enable the range to be still further increased, considerably beyond the horizon. If we assume that the principal calibre is 16 in., we must choose the best number of guns to be put on board, keeping before us the necessity of single salvos and also of successive salvos. Each salvo must be sufficiently numerous that there may be a reasonable probability of hitting—and successive salvos with a minimum interval, not only as regards the time necessary for the spotting at normal distances, but also as regards the rapidity of firing, which becomes necessary as soon as the shots have begun to hit the target. Calculation shows that the probability of hitting grows with the number of shots in each salvo, first rapidly and then more slowly; one can be more or less sure that with between six and nine shots per salvo one can reach the maximum probability of hitting. Therefore it is sufficient if each salvo has six to nine shots. The interval between each salvo is related to the rolling period of the ship (at least until we find some new mechanical means of firing), a period which varies in modern ships from 12 seconds to 14 seconds (complete double oscillation).

It is therefore evident that the number of guns on board a ship depends—the number of shots per salvo remaining constant—on the quickness of loading; if this loading is quicker than the rolling period of the platform, it will be necessary to have a larger number of guns than those required for each single salvo, whilst a number of guns equal to the shots of each salvo would be sufficient, if it were possible to reach such a speed of loading, as to ensure the firing of the complete salvo during the period of rolling. If we consider the ships so far built, we see that only half of the firing for each salvo is accepted, though sometimes we get the normal firing *in gran salva*, thus renouncing the maximum speed between the salvos.

It is known, in the Battle of Jutland, that the German naval artillery preferred to follow the system of quick-firing with half their battery, whilst the British artillery preferred, at least in some cases, the slower firing of the complete battery. If it were possible to reduce the speed of loading of all guns below the period of complete rolling, or better, below the half period of rolling, it would be possible, as already stated, to reduce the number of guns on each ship to correspond with the minimum number of shots necessary for each volley. This would reduce the number of large calibre guns on board our ships by about half, without in any way interfering with their offensive power. Therefore, there would seem to be a possible way of reducing the displacement of battleships in the near future, by building "super-rapid" gun-mountings, which would require only 10 seconds between each shot, and possibly even less. Although to-day this seems rather difficult to attain, it does not seem altogether impossible, if one does away entirely with all loading by hand, substituting mechanical loading from the magazine to the guns. The objections to the complete "mechanising" of the gun mountings, and of the loading arrangements, should vanish before the great advantages which could be gained thereby, and above all in view of the insuperable limitations of the Washington Conference.

Naturally a gun with "super-quick" firing would weigh considerably more than one of normal design; and therefore there follows the necessity of insisting on an increase in the number of guns of each turret, following the advice of our engineer constructors Ferrati and Masdea. The experience of our Navy and of the American Navy shows that the use of multiple turrets gives splendid results and justifies the proposal of Monsieur Doyère to employ quadruple turrets. One might think that the arrangement with independent guns, as in our Navy, might be more favourable for attaining "super-quickness" of loading than the American single mounting, but one cannot deny that a careful investigation of the latter does not give hopes of attaining this result, while retaining those advantages of weight that this type of mounting presents as compared with the previous one.

Although it appears possible, though not in fact already achieved, to arrive at such a reduction in the primary armament, we do not reach the same conclusion with regard to the secondary armament, destined for fighting smaller warships and aircraft. It is possible to have a single type of mounting, naval and anti-aircraft, in the guns of medium calibre up to 6 in., thus uniting the anti-aircraft and anti-submarine guns. Designs on these lines are already well advanced, so that the problem may be considered as already nearly solved. This fact, however, does not allow an absolute reduction in the secondary batteries, in view of the poor results of anti-aircraft firing, and of the ever-increasing development of smaller craft, as, for example, the new large destroyers of 2,500 tons and more. Therefore the actual number of guns in these batteries should be increased from the present 12 to 16, and even more, so as to have for each quadrant a number of pieces not less than four. It is also necessary to preserve these minor armaments in good condition during and after the battle; the practice of not protecting this artillery, as in England and America, does not seem advisable. It is therefore indispensable to fit them with turrets designed in such a way as to ensure rapidity of fire and the necessary elevation, or to adopt the system of well armoured disappearing mountings.

Naturally this protection must be proportioned to the attack and not to the calibre of the guns thus protected. Therefore, rather than consider a reduction in the weight of secondary armament, we must frankly face a considerable increase in this weight. In future naval tactics it will be necessary to provide for largely increased use of under-water weapons. It is known that endeavours are being made, and not entirely without success, to overcome the three principal obstacles which arise in the use of torpedoes: their limited speed in normal distances of battle; the visibility of their track; the poor sensitiveness of their fuse.

An increase in calibre would overcome the first difficulty, and torpedoes of 24 in. are already in use in more than one Navy; the employment of special means of propulsion may lead to the overcoming of the second difficulty, while a fuse with distant action, electro-magnetic, chemical, or some other system, is already being talked of, and may be the means of overcoming the third. May I be permitted to point out that the solution of the problem of the fuse acting without coming in contact with the target, which will enable the bottom of the ship to be hit, where it does not seem possible

* Paper read at the Paris summer meetings of the Institution of Naval Architects, July 4, 1922.

† *Rivista Marittima*, vol. liv, No. 8, page 271.

‡ The "Standard" displacement of the Conference does not include fuel and feed water.

* In the Italian Navy (differing from the English Navy) the weight of movable protection of the guns and the weight of the armour of decks are respectively included in the armament and the hull.

to provide suitable protection, may have a considerable influence on naval design in the future.

It does not therefore seem possible in future ships to give up the idea of under-water armament, just as it is not possible to renounce the secondary armament. Thus, in order not to interfere with under-water protection, and in order not to have an insufficient number of torpedo tubes, we shall have to accept torpedo tubes above water, as in the latest British ships, though possibly in a protected position.

I will not refer to the use of aerial torpedoes, like those of the Guidoni type, as they are not yet reliable. They seem, however, to constitute the best aerial weapons, at least for the near future.

Finally, as to the use of larger ships as platforms for aircraft, it would seem that this will have to be limited, at least for the present, to the smaller aeroplanes for reconnaissance and observing of shots, launched by means of catapults similar to those in use in the American Navy. As regards firing direction and spotting, it would seem that helicopters are likely to be more effective than aeroplanes. In conclusion, as regards offensive power, we may say that the only direction in which we can hope to effect the reduced displacement of future battleships is by a radical modification of the heavy artillery, which would allow of a diminution, to a certain extent, in their number. Reduction in the lesser armament and in under-water protection does not seem either possible or advisable.

Speed.—Whilst in the past the liberty allowed to each nation to build the number of ships preferred, made up of various units, one nation preferring the relatively slow battleship, to the more speedy battle cruiser, the decision of Washington establishes, especially for certain navies, such a small number of units of maximum displacement, that there is imposed on these navies the renouncing of these type differencies, and the building of ships all of maximum speed. This will lead to the fusion of battleships and battle cruisers, as was already the case in the Italian Navy, for other reasons, in the days of Brin and Cuniberti. Besides, the need to preserve a certain homogeneity in the few ships which are to be constructed after an interval of four years will be a further incentive to such a choice.

What is understood to-day as "high speed" is quite easy to comprehend; a speed of 30 knots is already exceeded, and it is not possible to go back. If obvious conclusions, such as the consequences of very high speed on various qualities of a ship, have any weight it might be advisable for a large navy to keep below the above limit, as, it would appear, the British Admiralty are doing after the example of the Hood. Can a navy with a limited number of ships renounce the only strategical and tactical advantages, which, with the same gun power, can be drawn from possessing a higher speed? This is certainly the most difficult and preoccupying point in the problem of future warships, as upon the more or less satisfactory solution of this problem the success of an entire navy may depend for years to come.

The results obtained with the latest engines give reason to the hope that still better results may be attained than those in recent ships; I refer to the magnificent results given by the engines of the light cruisers and flotilla leaders, both in trials and during the recent war. I would like to call attention to the results obtained by the Italian flotilla leader of the "Ammiraglio Mirabello" type. An exhaustive study of the possibilities which present themselves for the wider use of those engines in this type of ship was recently made by an eminent Italian engineer, Colonel De Vito;* where he shows that the adoption of engines of this kind would result in a reduction of more than 5,000 tons in the displacement of the Hood, leaving intact her speed, armament, and protection. This reduction does not seem exaggerated if one remembers that the weight per horse-power would be reduced from 36 kg. to 15 kg. (80 lb. to 33 lb.), and the space occupied in proportion. This splendid result—due to the marvellous progress of the Parsons turbine engines with oil fuel boilers—enables one to state that the above-mentioned speed could be preserved without excessive sacrifices, either as regards defence or attack.

Up to now we are in the sphere of present conditions. But we may look further ahead and observe the results which might be obtained with internal-combustion motors with heavy and reliable fuel. I would recall, for example, results which were published relating to motors of the Garuffa type, which lead us to hope that in future the question of high speed may be further facilitated. We must, however, remember that the reduction of only one of the several characteristics of a ship may give notable results, provided that this reduction is not excessive; it is obvious that, whilst reducing to nothing the weight of the engines of a ship, *e.g.*, the Hood, leaving other characteristics the same, its displacement would be a long way from being near zero.

The other element, allied to speed, is autonomy; the Washington Conference by fixing, as already stated, the "standard" displacement of battleships has taken away considerable importance from this element, naturally to the advantage of the ships destined to fight on the ocean. On the other hand, the adoption of liquid fuel, now more or less general and indispensable for high speed, enables huge quantities to be stowed on board. The British ships of the "Tiger" class, for example, with coal and oil, carried more than 6,000 tons of fuel. It is also to be observed that these thousands of tons, which do not appear in the actual weight of the hull, discharge a function of great importance as regard under-water defence. Therefore, as regards engines, and consequently speed, it will not be impossible to improve on past construction, though it is difficult to say *a priori* whether the said gain will compensate entirely for the greater sacrifice, viz., that of protection, which we will deal with in the next paragraph.

Protection.—If, at the Battle of Jutland, it seemed to some people that the best examples of modern naval technique presented a certain weakness as regards the defensive, what should we say to-day, when the American 16-in. gun, with almost double striking power, and perhaps even triple at long ranges, has taken the place of the German 12-in.? What shall we say in the near future, when by means of the normal and anticipated developments of the 16-in., this gun will undergo successfully the improvements by which in the course of the past twenty years the 12-in. gun has benefited, and if to this menace we add that of the new 24-in. torpedoes and of the new aerial bombs of 4,000 lb., what then? Let us see if modern science can give us that defence which will be necessary against attacks in three directions: Side protection, deck protection and under-water protection. For the side protection we must still have recourse to massive external defences. The experiments carried out by the British Admiralty with the ex-German battleships have shown that everywhere technical science has reached the same state of perfection; marked progress in this direction does not seem probable in the near future, unless unforeseen circumstances arise. As a defence against 16-in. shells, plates of equal thickness would probably be necessary, even for long ranges. This fact, in conjunction with the limitations of Washington, imposes on everybody the necessity to return to the old principle, to which the Americans were the first to revert, that is to say, to limit the vertical protection to the essential parts, reducing it elsewhere to armour of medium thickness, which would be of no use against attacks of heavy artillery. Nevertheless, the armour, naturally, must always be sufficient. Therefore, even by reducing the vertical protection to the indispensable minimum, no great advantage as regards weight can be obtained.

The utmost importance is given, and rightly, to the deck protection, as the horizontal target is by far the greater, not only in aerial attacks, but also against artillery at the actual ranges of battle. Whilst we may say as a sure guide that it is indispensable considerably to increase the thickness of the protection to decks, it would seem that some doubt still exists as regards the allocation of thickness in this protection.

Against artillery attacks it would seem advisable to follow the German example, and give the greater thickness to the lower deck, provided the turrets and the funnels are as adequately protected, whilst against aerial attacks some doubt may remain as to whether it is more convenient to concentrate all the protection in the upper decks. There is no doubt that if it were a question of resisting the attacks of simple perforating projectiles without high explosive filling or time fuses, concentrated protection on the outside would be the best solution, but owing to the fact that all projectiles, including aerial ones, have time fuses it would seem best to advise that the point of greatest resistance should be that where the explosion would take place. In other words, it would be advisable to sacrifice the part of the ship above the principal protective deck as long as one can, at any cost, save the one underneath. For this reason horizontal protection will always require greater sacrifices, and will not allow any margin of economy.

The under-water defence is now of fundamental importance, and is allied to the strength and stability of the ship. The three known fundamental solutions of the problem are: The bulge system proposed and experimented upon by General Ferrati in 1911, and largely used in the British Navy; the system of multiple longitudinal bulkheads investigated in 1892 by the late General Benedetto Brin, which is largely used in the American Navy; and the system of "hydrodynamic action" of Colonel Pugliese.* Other systems have been tried with success, but these three, which are based wholly or in part on metallic structures, and large masses of liquid, are those which have the greatest probability of being retained in the future, as the weight of liquid fuel is not included in the "standard displacement" of Washington. Here we see that the convention of Washington may have some curious results upon naval construction, almost as the tonnage rules have had upon mercantile ship construction. Under-water systems of defence present various good points as well as defects, which we do not wish to analyse here. They all have the common effect of protecting the side of the ship in a sufficiently satisfactory manner. By the fortunate circumstance that the devastating action of an explosion which takes place at the side of a ship grows much less than its weight, these defences will retain a notable utility in future, and already they can give adequate protection against the under-water explosion of bombs of 4,000 lb. and more.

But against this advantage the under-water defences have the inconvenience of being of considerable weight, and of limiting their protective action to the side of the ship. Owing to certain improvements in free and anchored mines, and in the pistols of torpedoes, with distant action, one will be obliged to provide defence for the bottom of the ships, and thus the side defence is not alone sufficient. The only means of limiting the extension of damage caused by explosion underneath the bottom of the ship, consists of a large number of airtight compartments. The system adopted by Masdea in the design for the first one-calibre Italian ship, Dante Alighieri, in 1907, that is to say, by dividing the hold into three longitudinal compartments, by means of two longitudinal watertight bulkheads united by transverse bulkheads, seems to constitute the best defence, when associated with certain conditions of static and dynamic stability. These examples of under-water protection are sufficient to enable one to understand that in this respect also it is not possible to anticipate notable reductions in the matter of weight.

A further system of defence will in future have to be provided, that is, against poisonous gas, whatever may be the consequence of the Washington Conference as to the abolition of this gas in future wars. Any kind of weapon, either guns or aerial, can fire on to a ship large numbers of projectiles full of poison gas, and it will therefore be necessary to provide an entire system of artificial ventilation, or rather, to form a zone entirely secure from the action of the gas in the whole ship. It would not seem sufficient to provide a defence against gas by merely relying on the gas masks worn by the *personnel*. This is an entirely new question, which will have to be thought out from the beginning of the building of new ships, so that the security obtained against this kind of attack may not be inferior to that provided against other kinds. It is difficult to estimate exactly what increase in weight this protection against poisonous gas may involve, but it is certain that it will not be small. All forms of protection are now assuming great importance, as shown by the fact that on a ship like the Hood, which is essentially an attacking ship, the weight of the protection alone is practically three times as great as the weight devoted to the offensive. One recalls the words attributed to Admiral Von Tirpitz: "Above all things the ship must float, and then float, and then still float."

It is difficult to foresee whether, in view of the offensive and defensive conceptions, which we have here set out, it will be possible to balance the one with the other so that they shall not cause an increase in the total displacement. But this result, which to us would seem satisfactory, and which probably might be carried out, would not come within the limitations of the Washington Conference. Let us see whether a consideration of the intrinsic qualities of a ship—her strength form, and nautical qualities—will lead us to less pessimistic results.

The strength of modern ships, with their ever-increasing length relative to their beam, the large inertia of masses situated far from the neutral axis and the great dynamic stresses caused by the high speed and firing of the big guns, present a problem of ever-increasing difficulty, which expresses itself in ever-increasing weight of hull, reduced only by making perfect the design and the material employed.

The requirements for a form, such as to give good nautical qualities, easy rolling motion and long period of oscillation, and also good manœuvring qualities, may find themselves in conflict with considerations of security. It might, for example, be agreed to accept large metacentric height, even superior to that of modern German ships, in order to ensure that a ship shall remain upright even with her sides or ends damaged. It would be interesting to discuss up to what point modern methods of fire control admit of counteracting the effect of great metacentric height, and perhaps even that of the excessive height of the guns above the water-line.

Finally, the form of the ship—long and narrow in order to attain high speed, large and low in order to facilitate the side protection and to allow room for the internal accommodation of ammunition and engines—may have some advantage as regards the diminution in the number of gun mountings and the space required for the engines. But these are modifications which are not of primary importance, and, as a matter of fact, radical modifications are not anticipated. As regards the intrinsic qualities of the ship, advantages can only be obtained by means of steady and continual perfectioning of the design and material. These improvements might, amongst others, relate to: (1) The use of more perfect materials; (2) the general use, if possible, of welding instead of riveting; (3) the incorporation of the protective elements with the structural ones.

As regards the first point, it would seem possible to obtain notable results, apart from the question of expense, and always with a view to limiting the displacement, by the use of special steels, better adapted than those actually in use, to resist tension, and, above all, the alternating and dynamic strains; the special vanadium and molybdenum steel already used for armour plates, is a magnificent material of construction. Its limit of elasticity exceeds 120 kg. per square millimetre, and with a margin of safety of 4, they would treble the strength of the structure, especially if made in such a way as to resist corrosion by means of suitable constituents. The result of adopting such a material would be remarkable, as almost 60 per cent. of the hull weight in a modern ship is devoted to longitudinal or transverse resistance.

As regards the second point, both the difficulties and the advantages of welding, as against riveting, are well known. To-day the welding of mild steel can be regarded as perfectly reliable, but as regards special steels, especially those above mentioned, grave doubts probably exist. One must not forget, however, that special steel for certain purposes can be admirably welded, and one should be permitted to think that in the future such an operation may be rendered easy and sure, with the consequence that the actual means of construction may be largely transformed, with a notable saving of weight, and more especially with enormous advantage as regards resistance to explosions and even perhaps to perforation. In resistance of the structure against explosion, under-water or by aerial bombs, the welding process has, I repeat, an influence of first-class importance.

The third point, however, is, in our view, the one which demands most attention, as it is the one which contains potentially the greater promise for the future. The co-operation of the protective material with that providing structural strength is already partly achieved in several navies, so much so that in certain of them the conventional weight of the hull includes part of the protective elements of the armoured decks. This principle has had an important application in the recent

* "The Technical Possibilities of the New German Fleet," in the *Rivista Marittima*, vol. lv, No. 1, page 33.

* See *Rivista Marittima*, vol. liv, No. 7, page 67.

German light cruisers, in which the sides were constructed of armour plate of a thickness of about 60 mm., embodied very cleverly with the rest of the structure, and with the various plates. The protective underwater structures, composed of one or more watertight bulkheads, flat or curved, and of great thickness, were an integral part of the hull, and they contributed greatly to the general structural strength. The advantage which may be gained by an extensive use of this system is evident, as we know how large a part of the total weight constructional items constitute: Hull plus armour (in the Hood) amount to 71·7 per cent., while in the pre-Dreadnought ship already mentioned (Regina Margherita) it is only a little different viz., about 70 per cent. Even a slight economy in this direction would give a considerable saving. If one were to obtain, for example, a reduction of 10 per cent. for a large modern ship, where hull and armour amount to about 20,000 tons, one would save a weight equal to that of an entire triple turret of 16-in. guns.

In any case, three points of such importance to naval engineering, to which we have referred, would produce results which can only be attained slowly, and as a consequence of investigation and experiments which will require considerable time.

The analysis which we have made regarding the various qualities, naval and technical, of the modern battleship does not leave us any illusions as regards the impossibility of being able to comprise within the limits of displacement fixed by Washington all the offensive and defensive power which at the present day would seem desirable. It would be well to note that, whatever may be the road which it will be necessary to follow in order to gain this object, two conditions must be observed: a systematic and profound study of all the material which is necessary for the construction of such a complex machine as the modern warship; very great expense, which may cause one to doubt whether the ship of the future of 35,000 tons imposed by the Washington Conference will really cost the various Governments much less than the present-day ship of 50,000 tons.

MECHANICAL VEHICLES AND ROAD SURFACES.*

By Brig.-Gen. The Right Hon. Lord MONTAGU of BEAULIEU, K.C.I.E., C.S.I., Companion.

THE cost of transport affects the condition of every country, and the cost of almost every article produced and consumed in it. Bad roads add to the cost of transport, and are a burden on the owners of vehicles though they do not always realise the difference in the cost of operation, maintenance and repair of their vehicles when used over good and bad roads respectively. The larger transportation companies are painfully aware of the facts, and comparative statistics show that often it would be desirable to abandon altogether certain routes where the roads cause abnormal wear. In other cases it would pay the owners of motor vehicles to combine to pay for temporary repairs, such as the filling up of deep pot-holes till the road as a whole can be repaired by the proper authority. The effects also of the surface over which vehicles pass are not confined to roads, and every locomotive engineer knows the difference which a good or bad road-bed and even or uneven permanent way makes in the cost of locomotive maintenance and repair. It is an interesting fact that it is only during recent years that the close inter-relation between the state of the permanent way and locomotive repair costs have been properly recognised on many of the great railway systems in Europe and America, and the expenditure on the improvement of permanent way definitely reflected in the diminution of engine failures and the locomotive repair bill. It is clear that if this is the case when smooth steel rails are employed as the surface for the steel wheel, the conditions of the road are much more important, when roads and road vehicles are considered.

There are four principal effects of bad roads as reflected in the wear and tear of motor vehicles. There is, firstly, the crystallisation and fatigue produced in all metal structures by constant shocks and vibration as, for instance, by pot-holes, corrugations, uneven stone setts, and other irregular surfaces. There is a definite and ascertainable deterioration of the metallic structure in axles, axle-casings, frame, cardan shaft, steering gear, and other parts of the vehicle specially subject to the road vibration. Most of the shocks, although individually of very short duration as a rule, are at the same time of great intensity in some cases. For instance, an ordinary three-ton motor lorry, weighing with its load about 7½ tons, at 15 m.p.h.—a very ordinary speed—has often to run through pot-holes sometimes as much as 2 in. deep, or over corrugations whose wave lengths, if the expression may be used, from the highest and lowest points are generally 9 in. to 12 in. apart. On modern roads there is an almost unyielding surface on the far side of these obstructions or holes for the wheel to strike. The blow at the point of the impact is often in force, as much as three times the weight of the vehicle, and in quite ordinary cases equal to one and a-half to twice its weight, or in the case of the 3-ton load vehicle mentioned an impact shock of 15 tons to 30 tons. This blow and shock has to be taken up first by the tyre, generally in the case of commercial vehicles made of solid rubber, which unfortunately, after a good deal of use, loses a large proportion of its natural resilience. After the tyre and wheel come the springs, comparatively stiff in character in the case of a commercial vehicle, which are compressed and relaxed quickly and constantly. Next in order to share in the shock comes the frame, and eventually the transmission-gear, the engine-bed and engine itself.

In the second place, there is the definite wearing of certain movable parts, which themselves have to move with shocks or vibrations, such as the leaves of the springs, the spring shackles and bolts, and wheel brake bands and brake connections. Again, the various rods and the worm-gear connecting the front wheels with the steering gear are in a state of constant movement. In the case of a heavily-laden vehicle, the spring shackles and bolts, unless they are carefully lubricated, show much wear in a short space of time, and when they become worn and loose in their fittings, not only is their wear accentuated, but a disagreeable chattering and noise is set up which, in fact, forms a great part of the noise nuisance which has lately become so serious in the case of heavy commercial vehicles. The body work is also strained and shaken over a bad road, and the fitting of doors, windows, and tail-boards affected.

In the third place, a considerable amount of extra power is necessary to propel a vehicle of equal weight and encountering wind resistance at the same speed over a bad road as compared with a good road. The extra power expended is due to the fact that the vehicle and its wheels have to be raised continually many inches or fractions of an inch after falling into every depression; in addition, side lurches produce unequal strains and wear the differential gears. Every form of vibration and uneven motion increases frictional resistance, which is again reflected in the consumption of motor spirit. From tests the author made, in the engine and gears, some time ago with a lorry carrying 3 tons, he is of the opinion that under bad conditions, such as on an uneven and muddy road, the consumption of motor spirit is increased by at least 50 per cent. compared with a good hard smooth road. On a road full of pot-holes and corrugations, but with a hard dry surface, the increase in consumption varies from 25 per cent. to 30 per cent. Besides the actual expenditure of energy involved by the continual raising of the vehicle, after its fall into pot-holes and hollows, the transmission of power from the engine to the road wheels is interfered with and proceeds in a jerky fashion, which is a contributory cause of diminished efficiency.

Fourthly, in the case of bad roads where the wheel is constantly interrupted in its actual contact with the road surface for fractions of a second owing to bumps and subsequent hollows, there is much extra wear and tear on tyres, on account of the tendency to sudden acceleration and deceleration in the rotation of the wheel, driven, as it is nowadays, by considerable engine power. This sequence takes place on every occasion when the wheel is not actually in close touch with the road surface. Again, the blow given to the tread and fabric of the tyres by uneven surfaces tend to make them wear out much more quickly, in the case of both solid and pneumatic tyres. In the case of solid rubber tyres the resilience of the rubber is gradually destroyed. Though pneumatic tyres undoubtedly damp down and neutralise small vibrations, and minimise to some extent larger vibrations, a really bad road causes severe strains on the rims, walls, and general fabric of these, and on the air-valves and security bolts, especially if there is any attempt to run at high speeds. Every blow also increases momentarily the internal air-pressure, though the exact increases of pressure are difficult to ascertain or express mathematically. But the author leaves it to the imagination as to what the strain on a pneumatic or solid tyre must be when a heavy vehicle, at considerable speed, encounters a succession of blows caused by obstacles, such as the far sides of pot-holes or corrugations in the road. The momentum of the vehicle, calculated in the usual way by multiplying the speed by the weight, is every time checked at the cost of shock and vibration. Probably the pressures in a pneumatic tyre rise for a second or fraction of a second to double or even treble their proper or usual amount, and it is conceivable that many of the bursts in the walls of fabric tyres and the loosening or bursting of cords in the case of cord tyres of the Michelin, Palmer, and other cord types occur when these blows are delivered. In the case of solid tyres the wheel of the vehicle strikes with a greater force than with a pneumatic tyre against any opposing surfaces, and the tyres in this case tend to split longitudinally or are sometimes partially wrenched from the rims.

In addition to these purely mechanical effects of bad roads, there is the considerable extra strain put upon the attention and endurance of drivers of vehicles, as there is a greater tendency to accidents observable in the direction of side-slips, skidding round corners, and failure of steering gear.

From the foregoing instances of how depreciation is occasioned to vehicles by bad roads, it is clear that well made and smooth roads are of great value to road-users. The direct interest, therefore, of the user of mechanical road transport in the construction and maintenance of good roads is very considerable, especially in a commercial sense. If in various countries the taxes for road improvement placed on motor vehicles were even heavier than they are to-day, the payers of those taxes would recoup themselves many times over in the consequent saving, were the roads they use put into good condition, and vehicles enabled to run over comparatively smooth surfaces instead of over uneven and rough surfaces which are now only too common.

One therefore comes by natural sequence to the problem of how smooth and strong roads can be provided for the mechanical traffic of to-day and the future. In the case of the heaviest motor-lorries their hind axle-weight amounts sometimes to as much as 6 tons to 7 tons, while traction engines running at a slow speed are allowed 8 tons on a single axle, by the law as it stands to-day in Great Britain. A load of 3 tons to 3½ tons on each wheel is possible and by no means rare. Such a heavy load should be borne not only on strong wheels and broad rubber tyres, but the wheels should be of comparatively large diameter, say a minimum of 3 ft. or 900 mm., heavily-laden wheels of small diameter being most destructive of road surfaces due to their small bearing surface on the road. But considering the universal tendency to-day to increase weights carried by each vehicle, the author is inclined to think that the time has arrived when the weights of the heavier road motor vehicles should be borne on more than four wheels. Already certain systems use six wheels, with the power plant separate from the carrying vehicle, and the use of trailers is also becoming more common, which ensures that the weight on any individual wheel is kept within reasonable limits. A further increase in the weight of any vehicle must necessarily bring about the employment of more axles and wheels, as has been found necessary in railway rolling-stock, where the average bogie passenger-carriage of to-day, weighing between 35 tons and 50 tons, with four wheels in each bogie, has its weight distributed over eight wheels. Consequently the old four and six-wheeled railway vehicles are disappearing, except in the case of small four-wheeled goods wagons carrying up to 12 tons only, which are run at slow speeds and for non-bulk traffic, and a few passenger coaches used on unimportant services. But it is an interesting fact in comparing road and railway vehicle practice, that as regards the latter to-day, the 40-ton bogie-carriage on eight wheels has, theoretically, a load of 5 tons on each wheel, whereas on some road vehicles not enjoying the advantages of a smooth, strong, steel rail the weight is sometimes as high as 3 tons to 4 tons. Considering its form of construction and weaker resistance to shock it is unwise to require a road to bear a far greater comparative strain than is borne by the steel rail. In saying this, the author does not forget that, in the case of locomotives in Great Britain, the axle-load sometimes amounts to as much as 20 tons, or 10 tons a wheel in the recent and more powerful types such as the new Pacific type on the Great Northern Railway, and 19½ tons in the case of the newest London and North Western Railway locomotives. Weights up to 20 tons have been allowed since the 1908 curve, as it is called, was adopted by the Railway Engineers' Association. But locomotive engineers have been, and are, endeavouring to reduce weight per wheel in order to save expense in permanent way and get greater adhesion.

In conclusion, it must be borne in mind that the problem of making roads strong enough to withstand the increasing strains, to which allusion has been made, is to-day one of finance, and only in a secondary degree one of engineering. Most competent modern road surveyors and engineers, if given sufficient money, can make a road strong enough to stand almost any strains and its use by vehicles at almost any speed. But to make such a road is very costly, and the expense increases rapidly if heavy weights at high speeds have to be provided for. Already roads specially surfaced cost as much as 15*s.* or even more, per superficial yard in the case of main trunk roads through country districts, and as much as 30*s.* to 40*s.* per superficial yard in the case of much used streets in towns, which are paved with stone setts, wood blocks, or asphalt laid upon concrete foundations. It is clear that in over-taxed and over-rated Europe such a cost cannot continue to be provided except in special cases where the heaviest and most constant traffic exists, and if only these expensive surfaces last for a really considerable period of years during which no repairs of any consequence are necessary. A cheaper form of road-making is therefore very desirable if we are to continue to improve our highways in strength and smoothness, and road traffic is to be worked economically. Any highway engineer or highway construction firm who can lay down a road in the neighbourhood, of, say, 5*s.* per superficial yard for the ordinary main trunk road, will deserve the thanks of all motor-vehicle users, as well as of the suffering tax- and ratepayers. The author is inclined to think that most of the present system of road-making by what is known as single or double carpet work on specially prepared foundations is too expensive for our present impoverished state. Economy as well as efficiency will, it is hoped, be secured eventually by some other cheaper process.

Improvements in the methods of road-making and in the diminution of cost are of immense present and future interest to the users of mechanical vehicles, for governments and local authorities are finding it increasingly difficult to obtain money to spend on road improvement and maintenance. It is, at the same time, incumbent on designers and makers of mechanical road vehicles to spread the weight of their vehicles over more wheels if possible, and to limit the total weight borne on each wheel to say 2½ tons as a maximum.

The author has shown the cost of bad roads to every owner and user of a road vehicle, and each nation as a whole has eventually to pay more for the extra cost of its transport under such conditions, which in turn increases the price of every kind of article to the manufacturer and consumer. To save this waste there must be more co-operation between road-makers, designers of road vehicles and road users, to promote economy in the upkeep and improvement of roads, which at once reflects itself in cheaper transport. Otherwise the road and the vehicle alike will suffer, and no prudent man can help seeing that there will be increasing difficulty in finding money in the next few years for road construction and repair. Bad and rough roads entail an extra burden on the community as a whole, for which every vehicle owner, road user, consumer and manufacturer, has to pay. Every nation therefore is directly interested in keeping down the cost both of road-making and the use of vehicles upon the road.

* Paper (slightly abridged) read at the Paris Meeting of the Institution of Mechanical Engineers, June 14, 1922.